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POWER

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APRIL, 1937

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STEAM GENERATION · POWER GENERATION · WATER POWER · DIESEL & GAS ENGINES · AIR CONDITIONING & HEATING · REFRIGERATION · PUMPS & COMPRESSORS · STEAM SERVICES · ELECTRICITY & ELEVATORS · INSTRUMENTS & CONTROL · PIPING SYSTEMS · MECHANICAL TRANSMISSION · POWER MISCELLANY

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A glimpse into the world's largest turbine workshop

MAGNETIC DETECTION

LET'S stop awhile and watch this inspector at work in the General Electric turbine workshop. His job is to check each turbine bucket against G-E standards of quality. It is another example of the painstaking attention to detail that makes General Electric turbines outstanding in service.

These turbine buckets are being tested magnetically to detect hidden defects that would be invisible even under a powerful magnifying glass. Immersed in a bath containing iron powder, the tray of buckets is first placed in the coil at the inspector's left. Power is applied, and the buckets are magnetized. Then the inspector removes the tray and begins his scrutiny. Any minute crack will form a tiny magnet, and a fine line of iron powder will definitely mark the defect. Each bucket is given a rigid inspection before being demagnetized and passed for other tests. No crack or flaw escapes the inspector's careful examination—the magnetic test assures a turbine bucket that will meet the severest service requirements.

Magnetic detection is but one of the many tests used in the General Electric turbine workshop. These multiple checks guarantee quality. Their value is proved by the performance records of General Electric turbines.

GENERAL

P O W E R

A McGRAW-HILL PUBLICATION — ESTABLISHED 1882 — PHILIP W. SWAIN, EDITOR

Speaking of Power

Floods—The managing editor returned from the flood area with a bag full of notes and photographs and a left arm still sore from typhoid inoculations. Here are some of the things he saw and heard:

Necessity, they say, is the mother of invention. The floods proved it. Louisville's water plant needed some wading pants in a hurry and radioed the request. Someone thought of the local Baptist minister and the waders were on the job in half an hour.

Men will work harder and safer in emergency. Darwin S. Brown, of Cincinnati Gas & Electric, told Tangerman that the West End and Columbia plants had no accidents during the flood.

And here are some practical lessons: First, history isn't always a safe guide. Much valuable electric equipment was lost because it had been raised only slightly above the level of the previous highest flood (1884). A few extra feet of hoisting would have been mighty good insurance.

Second, beware of empty tanks. When floods threaten, anchor them solidly, fill them with water, or leave top and bottom connections open so that they will fill themselves as water rises. Floating tanks of all sorts caused endless mischief.

Gasoline pumps were unsung heroes of the flood, pumping water into boilers and out of flooded sumps and cellars.

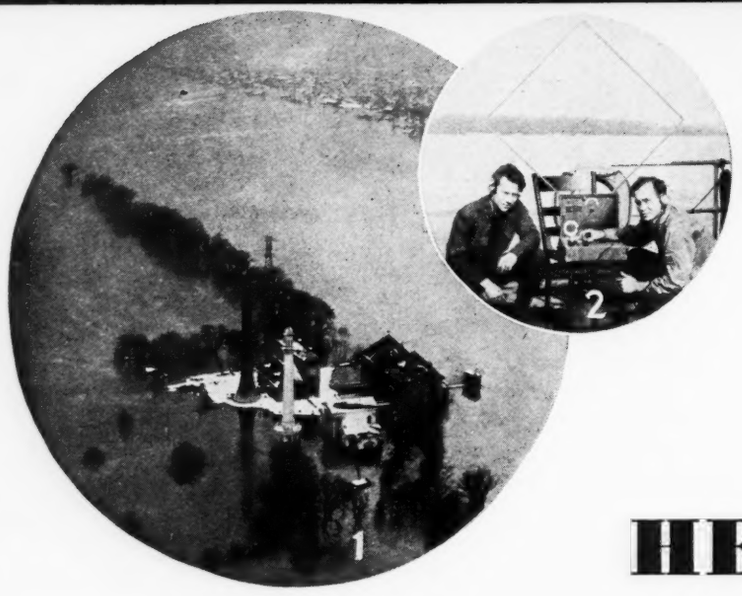
Smoke—A good friend in London gives us an interesting slant on the British smoke situation. Because of countless thousands of domestic grates burning soft coal, their condition is worse than ours, but they have done much more to correct it, at least in large power plants. I use "smoke" to include fly ash and sulphurous fumes. Stack gas from London's Battersea and Fulham Stations takes a terrific scrubbing before it enters the atmosphere. This cleansing is costly and compulsory. The ruling "no smoke or no plant" was necessary to protect the population and such delicate historic structures as Westminster Abbey, already much damaged by sulphurous gas. Yet England will never really lick this problem until she can do something about domestic open-coal fires.

Welding—Ordinarily, we don't get overheated at prize contest announcements. If $1,000 is offered for a new name for chewing gum and 100,000 contestants enter, anyone can figure that the average contestant's chance is worth one cent.

How different is the competition announced by the J. F. Lincoln Arc Welding Foundation? Here the awards reach the stupendous total of $200,000. Contestants must write of welding applications from first-hand experience, which means that the non-engineering public is, in general, automatically excluded. If, with this limitation, there are 1,000 contestants, each man's chance is, on the average, worth $200, enough to justify a lot of midnight oil. Even with 4,000 contestants, the average chance would be worth $50.

Many power engineers will enter this contest, particularly under the classifications of "functional machinery" and "industrial machinery", where a total of 108 prizes, totalling $50,600, will be awarded.

Oil—An expert in lubrication passed us a good tip the other day. "Why don't you tell designers to design machines for lubrication? As often as not, the machine is half built before somebody remembers that it won't run without oil and grease. Then he drills a few holes, cuts a few grooves and calls it a day". Oil people are doing some wonderful research today, but these design oversights waste half the benefit.



Army radio (2) kept Louisville's water plant (1) in touch with the world (Louisville Courier-Journal photo)

HELL in HIGH WATER

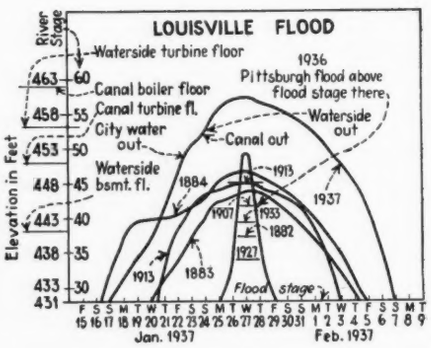
A blow-by-blow account of the battle between power men and the deluge at Louisville and Cincinnati. General statistics appeared in *Power* in March

By E. J. Tangerman

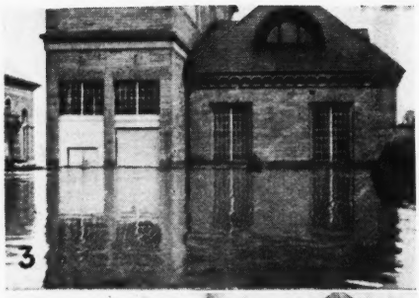
Managing Editor

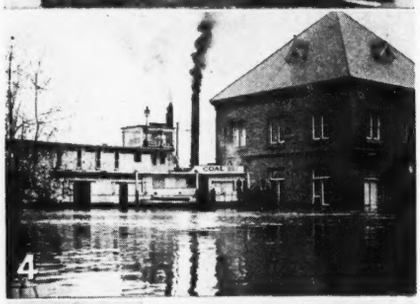
LOUISVILLE'S pumping plant (1) is 5 miles above town on the Ohio, lifting water to Crescent Hill filtration plant. In No. 3 unit (No. 1 is abandoned) are three pumps drawing from the same dry well; a 60,000,000-g.p.d. electric centrifugal, a 40,000,000-gal. turbo-centrifugal, and a 30,000,000-gal. triple-expansion crank-and-flywheel type. In No. 2 station next door are a 24,000,000-gal. crank-and-flywheel unit and a 16,000,000-gal. compound walking-beam unit with 36-ft. flywheel, the country's largest. Here water rose 4.5 ft. over the operating floor, which itself is 7.4 ft. over the 1884 flood crest. When utility lines failed Friday morning, Jan. 22, the electric pump went out, to be followed by the turbo-centrifugal when flood waters covered the steam lines. With the last plant steam, the crew hoisted the motor for the electric-driven unit, but not enough steam was left to get it above the operating floor. A flooded boiler-room basement (3) Saturday evening finished the steam part of the plant.

Next morning, a river steamboat (4) was backed up to the windows of No. 2 unit, over what should be dry land. By 6 p.m., its four 500-sq.ft. boilers were supplying enough steam to get the 24,000,000-gal. crank-and-flywheel unit rolling over, and water passed the weir of Crescent Hill reservoir 1½ hr. later. Four sections of 1½-in. steam hose from the L & N Railroad were connected through 1¼-in. nipples to the header, but the hose kept blowing out, each time causing shutdowns (longest 4½ hr.). Finally, two sections of 1½-in. pipe with Moran ball-and-socket joints were put in instead (10), the pump operating on one while the other was extended as the water fell, though steam pressure at the pump was only 125 to 150 lb. with 225 to 250 lb. at the boilers.



The old pump, erected in 1909, that did such yoeman service is an Allis-Chalmers unit with 30-in. H.P., 56-in. I.P., and 80-in. L.P. steam cylinders and 60-in. stroke. Its main shaft, with two 18-ft., 40,000-lb. flywheels, is only about 3 ft. above the engine-room floor, so the unit ran more than half submerged for about 5 days. The gallery below the operating floor floated plank by plank into the flywheel, at first interfering with starting, later being splintered to matchwood, then thrown in bits all over the room, op-





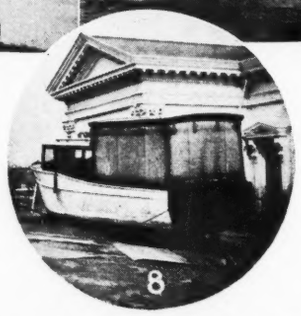
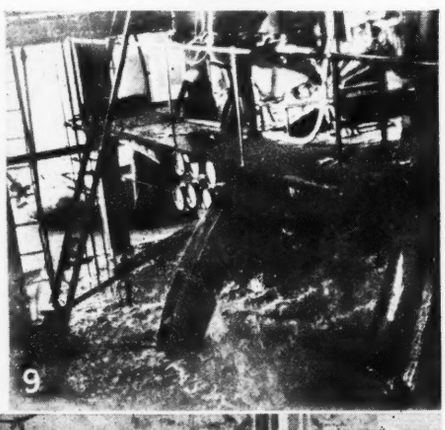
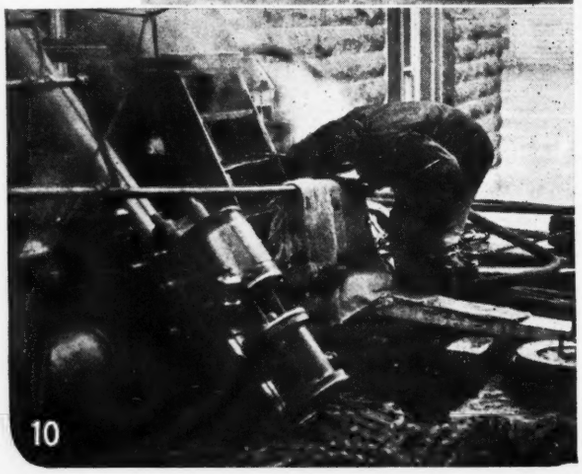


Fig. 5 left





2 ft. of water in the boiler room (3) covered steam pipes, but a river steamboat (4) supplied steam to a pumping engine with main bearings 15 in. under water (9) through the Valley's worst flood (5). The boat captain, from his deck, hung the bushel basket on a tall tree that was then a bush (6), while new mechanical screens in the intake tower (7) got a washing. Steps and pipes led from boat boilers and railroad air compressor to pump (10). A cruiser (8) ferried supplies from town to plant

erators or no operators. For 4½ days, the pump operated with its main bearings unlubricated (9), but that took too much steam to start up after a shutdown, so 9-ft. lengths of ¼-in. pipe were set into the oil holes. Then the oil cups were set on top, providing sufficient static head for lubrication.

At one time, a poppet-valve stud broke, but the pump couldn't be shut down, or Louisville would be waterless. So the welder bronze-welded it as it operated, catching the stud during its 1-sec. dwell each revolution. It's still working! B. E. Payne, superintendent, once radioed for wading pants, easy to get in the East where every third man is a trout fisherman, but scarce as hen's teeth in Louisville. But in a half hour, Joseph D. Scholtz, president, had wheedled a pair out of the Crescent Hills Baptist minister, and they were on their way. Another time, Mr. Payne wanted an air compressor, but didn't say what kind. A half dozen frantic messages finally resulted in agreement on a steam-driven compressor off an L & N locomotive, small enough to be carried in a 15-ft. skiff. Mr. Payne needed it to supply air to the pump discharge chamber (otherwise it would blow out the head) and for cushioning the upper 30- to 40-in. diameter poppet valves (lowers have springs). The regular compressor was ruined by waves (created by the pump flywheel) which entered its intake. Mr. Payne got to using radiator pipe, fittings, and whatever else he could get loose to keep things operating. Communication was difficult; two Army radio operators got cauliflower ears from their headsets.

Once, the river threatened an ornamental balustrade. Mr. Payne radioed for sacks, which Mr. Scholtz got from Louisville Gas & Electric, but then found he had to use coal instead of sand in them.

As the water dropped, the boiler house was a sorry mess, beginning Mr. Payne's series of real disappointments. Steam lines to stoker engines were gone, belts had shrunk, and the worm gear on the chain-grate broke due to ice. The worm and gear off the adjacent stoker were of opposite hand, so they had to stop and weld. To fill in, they started up some condemned boilers and used them until a piece of coal gate and several tubes went out, blowing steam all over the place.

Meanwhile, the boat captain was getting fearful of land beneath him. They had to drop a dinghy through a floor grating to oil the stoker driver shafts, but they got steam up Wednesday morning, Feb. 3, enough to start the 30,000,000-gal. unit at 10 a.m., and to release the steamboat at noon. Two days later they had the 16,000,000-gal. unit going. When No. 3 flooded, sump-pump valves had been left open, so as soon as steam was available, they pumped themselves out, uncovering the turbo-centrifugal and the lower half of the 30,000,000-gal. When I was there, the danger was of supplying too much water, increasing pressure so that flood-damaged mains burst. As it was, there were several first-class washouts.

Louisville Gas & Electric

Louisville's two major interconnections come in along the river, so floating debris and tank cars took them out early in the struggle. But one high line was reconnected through some 0000 distribution lines to supply the radio station and a dairy, and kept in all through the flood. The line across the Ohio from Indiana also had to be cleared of debris. At first they tried dropping men down the flood past the line in skiffs—when the man fell overboard or the boat was torn loose, a steamboat in the channel below picked him up. But that wasn't very successful, so they lashed a barge to the boat, and inched their way along the high line, fighting an 8-mile current all the while!

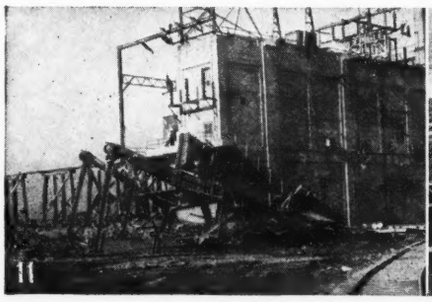
Ohio Falls hydro plant, when I visited it, was clear of water to the main operating floor only (15). C. B. Royer, chief engineer, was busy directing gangs of men hosing down the generators and loading muck and debris into wheeled buckets for hoisting out and dumping. Luckily, Mr. Royer had ordered that the discharge of a 10-in. pump be left open and its diaphragms on the suction side fixed, so that when the water went down, the plant pumped itself out from the 460-ft. crest to 418 ft.—42 ft. After the 140 men get the main floor cleared, water will be pumped out below, but until then it is left there to keep muck soft. About 5 generators should be rewound; the rest will probably be dried by shorting the fields.

Canal Station

This 18,500-kw., 25-cycle station was taken over from the street railway in 1930, and is now being increased by a 25,000-kw., 60-cycle unit. E. G. Rosenbaum, plant engineer, told me the station was tight to its design level (52 ft.) 5 ft. over the 1884 flood. Sandbagging and bulkheading against doors and a temporary sheet-iron west wall held it to 2½ ft. over that level, but the face brick was blistering off the wall between turbine and boiler rooms and the station lost cableway, blowing up a couple of circuits and endangering the rest. After the station shut down, they jacked ashpit doors open, then sent all but 32 men home. These lifted a steam-driven exciter 10 ft. above the highest previous flood level with the last available power, then choked boilers, leaving some fire to avoid freezing. Later, the flood rose for 2½ days more, just touching the base of the exciter, and submerging the main units except for the thickness of the top of the generator frames.

These 32, living at the plant 12 to 16 days, nevertheless kept high morale. A firebrick stove connected to a blocked-off boiler (for a flue) did their cooking, and a U of steamline down into the flood and out again provided boiler-treatment-tasting, but cold, condensate for drinking. Two truckloads of food, mainly fruit juices, ham, sausage and cheese, had been brought in before the water got too high, so they lived like kings, swapping yarns around the camp-fire every night. Some got anxious about their families, so took the housing off a gasoline pump, drilled the impeller and a feedwater-regulator diaphragm with three holes each to make flanges, and connected the engine to a motor-generator set. Then they could charge station batteries and provide a little light and power a radio salvaged from a flooded automobile. Other men lifted conduit out of the water, and combined it with Dresser couplings and some radiator piping to rig a "haywire" steam line from boiler room across turbine room to office and dressing room, with a lifted locomotive injector feeding one boiler. After that, they came off their top-of-boiler bunks and slept like gentlemen on the dressing-room floor.

The water finally reached 19 in. under the boilers, 4½ ft. under the office floor,



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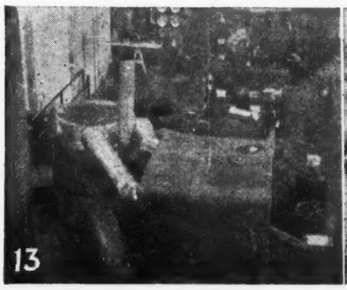

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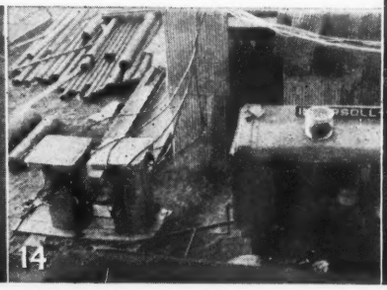

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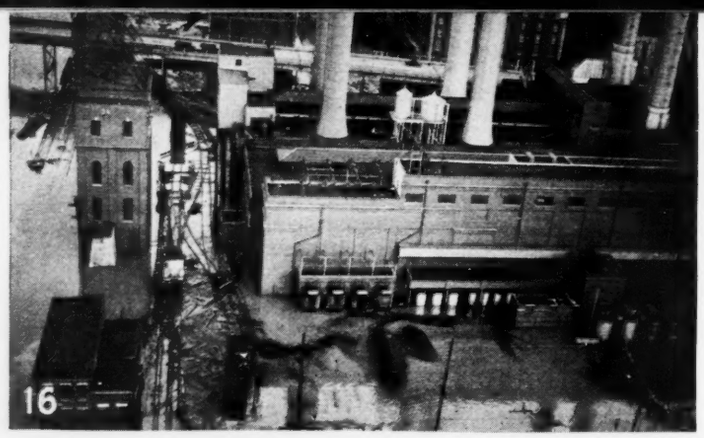
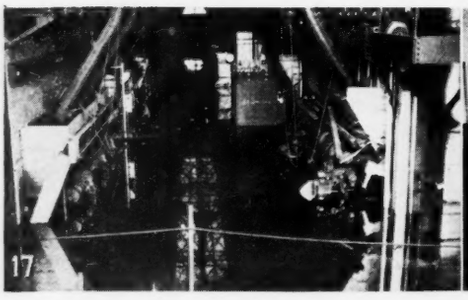
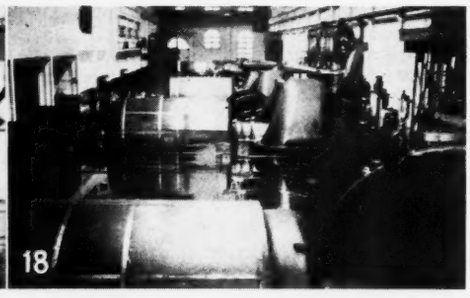
15

At Ohio Falls hydro plant, logs battered in upstream windows, and water followed to well over the generators (note waterline in 15), also overturning gantries (11) and washing out the spur track (12). At Canal, one of three household hot-air furnaces dries out an exciter (13) beside the big vertical frequency changer (left), while gasoline engine, transformers and air compressor outside provide service (14). Pipe was for pumping out. Fig. 15 is a Louisville Courier-Journal photo.



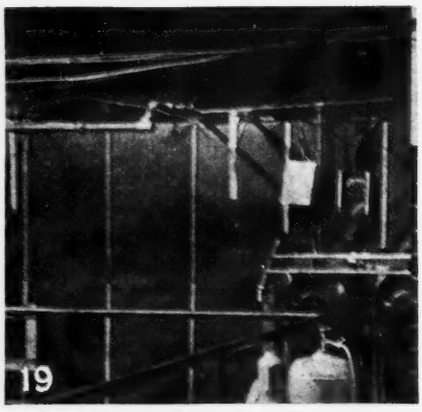
For 36 hr. before Waterside (Louisville) failed, coal was brought in by truck along the municipal bridge, dumped, then hoisted over the side into a coal car by a bulldozing Caterpillar tractor with grab bucket (16). But water rose 4 ft. in the boiler room (17 — note high-water mark on switchboard) and above the shafts in the turbine room (18)



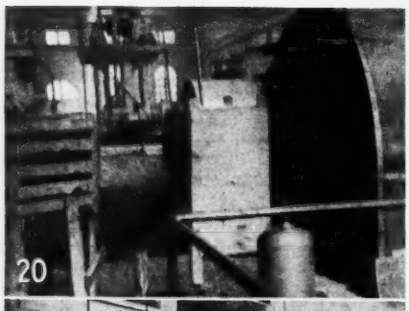


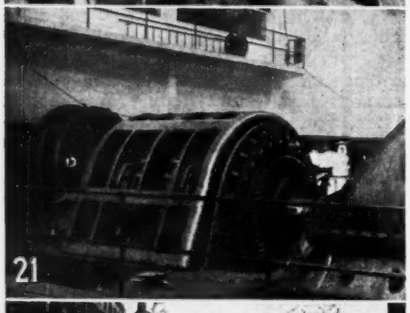
then started to recede. Some of the venturesome boys dropped down river in the skiff, then were proudly towed back by a Coast Guard boat with 30 chickens and some feed—which meant meat on the hoof until the boys got chicken-hearted after the chickens started to lay. When the river went down a little more, two more boatloads of food were brought in.

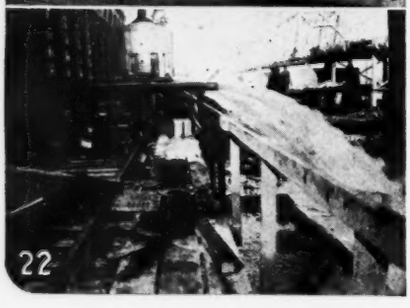
Regular sump pumps were submerged, so gasoline pumps removed station water 30 to 40 ft. ahead of the river after it dropped below design level. Dresser couplings on 4- and 6-in. pipe avoided threading and time losses. The oil crest on the flood was gotten out by breaking a few upstream windows to let the current through.



When the men saw the fight was useless, they tried to save one generator (21) but the water caught them after 5 hr. with 2 hr. more work to do. So now, it's remove fields, drain and dry lead holes through shafts (20—one had 6 gal. of water), and dry small parts in special rooms (19), while the basement is pumped out (22)







When the river got low enough, several men waded over to Hart Mfg. Co., across the street, where the manager, just arrived by boat, gave them three ordinary hot-air furnaces. Coke-fired these prevented generator icicles, served as cookstoves, and when I was there were being used for drying out. Feb. 11, one unit had been turning over.

Mr. Rosenbaum's outstanding recollection is of the rushing flood waters on his turbine floor and of the loud night ticking of the clock as they waited for the flood to crest. He learned from the flood never to be aggravated and to have patience, also that men can work harder under stress than at any other time, and stay in good spirits in spite of the Hell they undergo. They even managed a cheer when the dry exciter supplied enough power for the crane to lift their skiff out of the dried-out sump.

Waterside Station

Waterside installed its prepared bulkheads for 2 ft. above the 1884 flood, but water eventually stood 3 ft. deep on the turbine-room floor, and got into the boiler furnaces, the crest of oil on the flood starting a serious fire from residual heat in the brickwork 28 hr. after the station had gone down. They finally got it out with firehoses supplied by gasoline pumps they had taken up into the control room.

John Hurst, mechanical operating engineer, and Joe Brown, chief engineer, kept 100 men in the plant through it all. As the water rose, a negro, scared almost white, ran in to report water showing a foot deep on the crusher-room window. It wasn't possible, but Mr. Hurst went to look, and there it was. The window had been so covered with coal dust it had been missed. So they dropped a tarpaulin outside to prevent sudden inrush of water, then bulkheaded.

Water got something like 12 ft. high outside, and a basement floor started to bulge up. 8x8-in. timbers braced it from the floor above and it held. Then, in the middle of one night, a front door started to fail. A blast of the steam whistle brought the men down barefooted from their sleeping sacks on top the boilers; they reinforced with hastily brought sandbags; it held three days more. Later a crack developed on the north basement wall, through which a sheet of water came pouring. The only wall for bracing was plaster, so useless, so they set two men to watch and warn. Then a steam duct cracked, and other walls began to fail, so that water began to come in faster than they could pump it out. Black Sunday morning, Jan. 24, at 11 a.m., the operators cut the curb on the 25x20x200-ft. ashpit and diverted excess water there. In spite of six steam pumps, it promptly filled. Then they cut the curb to No. 2 condenser well, 60x60x60 ft., then to No. 1 well, 25 ft. in diam. by 50 ft. deep, in each case opening condenser hotwell drains so water could come in and avoid tipping condensers.

But by now water was "raining" in through conduit openings, and it came over the edge of the curb on the last condenser pit. So, at 8.3 ft. over the 1884 crest and 7 ft. over design level, the men had to yield. The switches were pulled at 11:39 p.m., and the turbines went down 5 min. later. They emptied ashpits and filled the 2-carload bunkers by the truck-bucket-car system of Fig. 16. When

Louisville stations have semi-permanent bulkheads for lower windows (23), but this time the water went over them. Louisville Courier-Journal photo

the water receded, gasoline pumps worked against 50-lb. pressure to supply boiler feed, so the plant had steam up at 455 ft. (Mon., Feb. 1) 13 ft. before the boiler-feed pumps were uncovered. Gangs of negroes operated the chain-grate stokers by hand and got boilers about up to rating, starting a new boiler as bunkers on one emptied. And operators found that, though they'd boarded, blocked, and sandbagged turbine-oil tanks, the water had gotten in anyway, replacing their oil with 4 or 5 ft. of water and mud. And shaft holes through which leads pass to generator fields were full of water—in one case 6 gal.

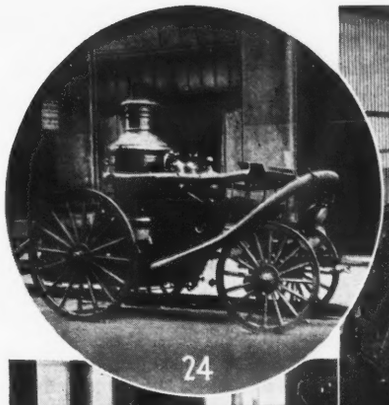
General

Fred Marx, at Heekin Can Co., Cincinnati, had no water for his boilers at one time, but flood waters began to seep into his basement, providing a new source of boiler feed until the flood receded. When his company got a Red Cross order for canned beans, he borrowed a 40-hp. synchronous motor and a 40-hp. d.c. motor and tied them together into a motor-generator set, powered by his own d.c. generator (he buys his a.c.—about ¾ of the total, but had no supply during the flood). Another chief supplied his boilers with water from useless city fire mains.

At Louisville, Brown Hotel used a V-8 aviation engine cooled from a tank truck to supply lights; other companies used everything from diesels to one-lung gasoline engines. Among the companies which had Caterpillar sets were Brown & Williamson Tobacco Co. with its 2,500 refugees (44 hp. for pumping and 20-kw. to power a cigarette line). The 20-kw. set delivered 28 kw. through a wooden switchboard until the police radio system failed, when it was requisitioned for service there, to direct rescue work. Tube-Turns, Inc., C. G. Dearing Printing Co., Standard Gravure Corp., also had such sets.

At Louisville, the L & N Railroad set up two locomotives to heat (with Modine unit heaters) and light its station and offices, and the Department of Agriculture sent in five gasoline-generator sets to power bakeries and dairies. And Henry Vogt, as reported last month, powered two bakeries, two hospitals and a dairy.

Cochrane Corp. had about 100 flowmeters ready to ship to Cincinnati Water Works, which luckily hadn't been sent, so missed a soaking. And McDowell Paper Co., Manayunk, (Phila.) Pa., has just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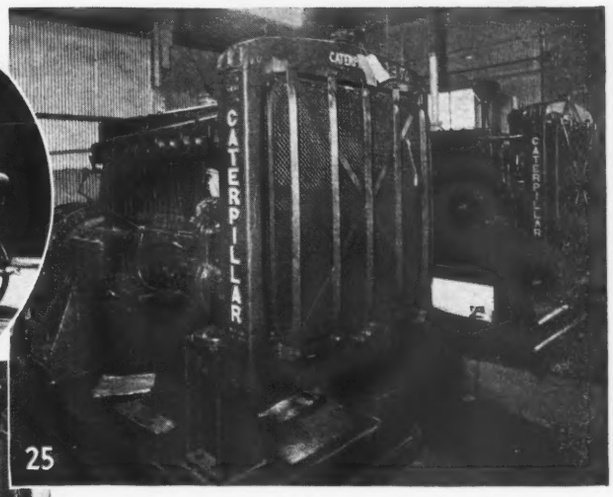

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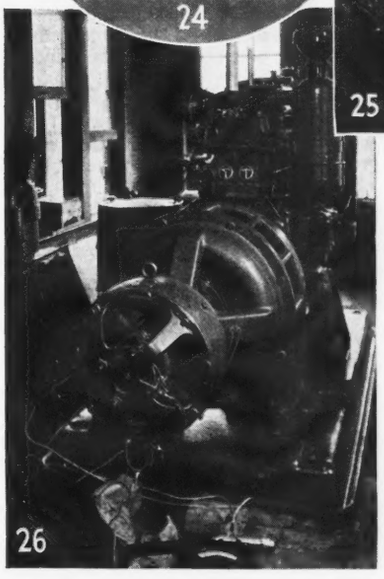
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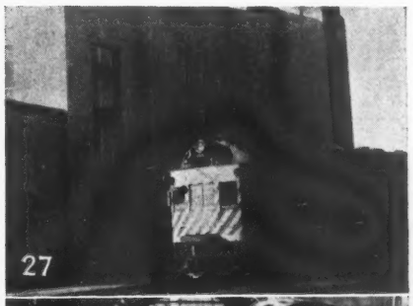
As the water receded, anything that would pump was resurrected (24). Caterpillar diesel sets had been brought in; two at Tube-Turns Inc. (25) provided lights for 2,500 refugees in company warehouses, another powered C. Lee Cook Co. (26), while a diesel locomotive powered auxiliaries at Cincinnati Union Terminal power plant (27) and Wm. Powell Co. dried its generator (28)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At Brown Hotel, Louisville, a V-8 aviation engine with tank truck for cooling water (29) provided flickering lights, while a diesel powered the telephone exchange (32—Courier-Journal photo). In Cincinnati, one plant engineer cut generators in on the driveshafts of two old Essex $25 trade-ins (30), throttling as necessary to power his drying-out ovens, while G. E. built a regular production-drying oven (31)

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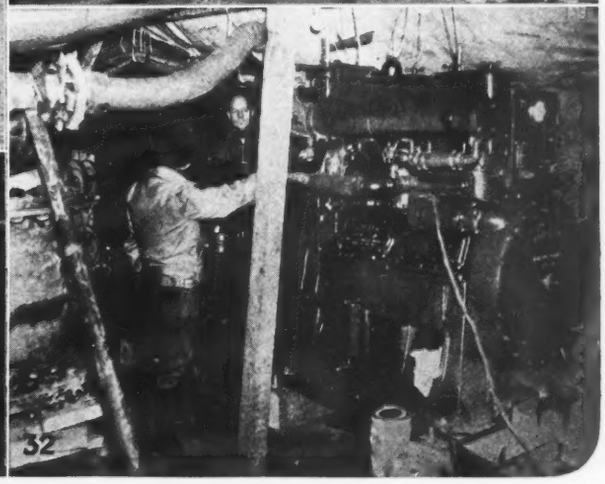
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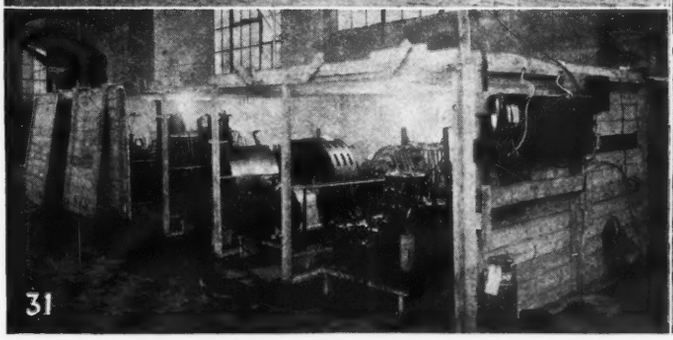
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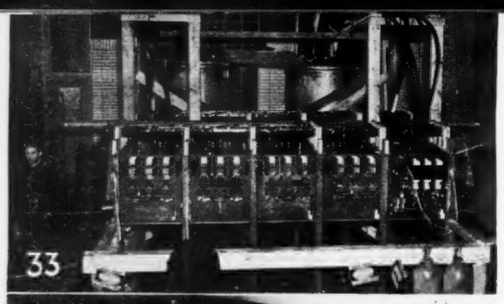
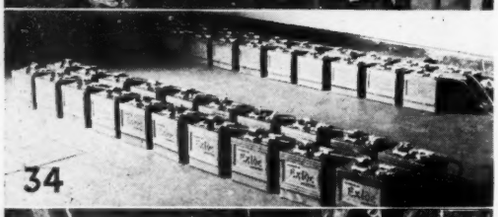
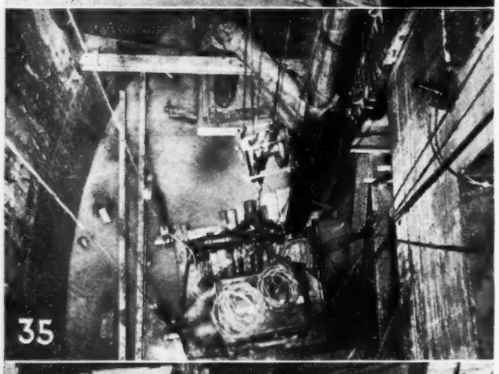
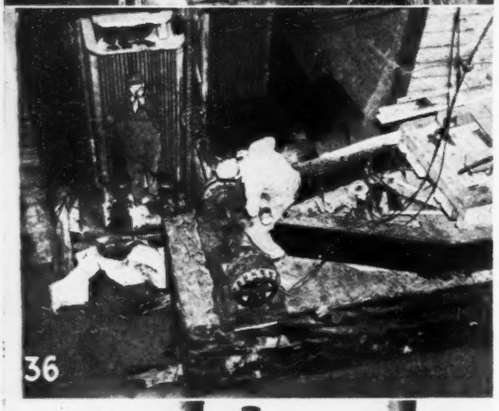








installed a Hays-Carrier-Cochrane instrument panel in its oil-burning plant, equipped with panel hooks on upper carriers, and unions in pipe and conduit connections, so that the whole business can be hoisted out of floods. These are examples of repercussions elsewhere in the country.

Cincinnati Gas & Electric Co.

West End is being increased from 144,000 kw. to 179,000, and luckily all construction crews were in the plant during the flood. Carpenters built the walkways (37) and across these the auto batteries for temporary control and the pipe for pumping out were brought. Only pipe available was 40-ft. lengths of 12-in. spiral-welded pipe. Trucked to the tipple, it was then cut into 10-ft. lengths, so two men could carry them across the walkway. In the plant, it was welded into 20-ft. lengths, with square pieces of ⅜-in. plate cut from a coal bunker for flanges (35). Soft-rubber gaskets sealed these crude joints.

Pumping out was done by two scrapped 3,200-g.p.m. @ 90-ft. head pumps (from the former hydraulic vacuum-jet system on one condenser recently converted to steam jet). When the pits were abandoned, the service-water pumps (about 750 g.p.m. @ 300-ft. head) were reconnected as sump pumps and all lower valves left open. Thus when pumps on rafts got water down to 30 ft. in the condenser well, the steam valve on the service-water pump was cracked slowly to avoid water hammer—and the pumps pumped themselves out! They discharged about 1,000 g.p.m., because enough spill was opened to keep pressure down.

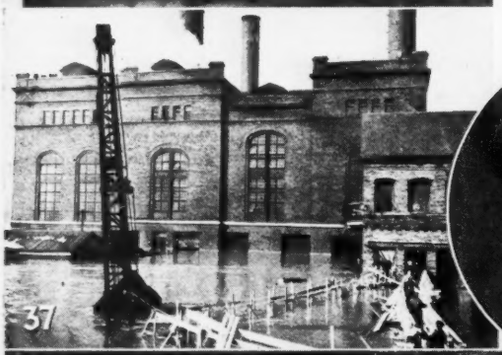
Temporary substations (33) and control batteries (34) were still operating when I was there Feb. 8, and gas-fired drying ovens were busy with electrical equipment, two of the biggest jobs being 600-hp., 300-r.p.m. motors. No generators, busses or big breakers got wet. At one time, gasoline floated into the boiler room, so a downstream door had to be opened to float it out again.

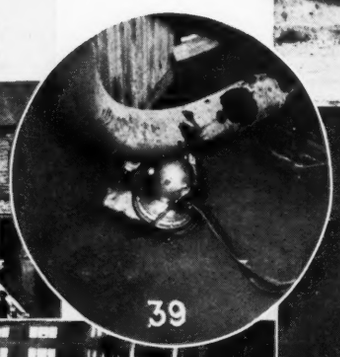
Columbia was so isolated at the crest that supplies had to be ferried four times to get to it at all. But Engineer Joe Heimbrock also had a construction crew there. Water rose 8.5 ft. in the basement, flooding out auxiliaries, control batteries, and air compressors (for the bin system of pulverized-coal firing). The motor-generator set and Ward-Leonard control in the coal tipple were flooded out, as were pulverizer grinder motors, and three buss rooms, each with 36 big breakers. Busses were just out of water, but control relays, contactors and transformers went under, replacing oil in transformers with mud. Leads from transformer banks supplying auxiliary power were submerged before the crest, but new lines were run down through a window and the motor-generator set supplied d.c. for coal feeders and the primary-air fan.

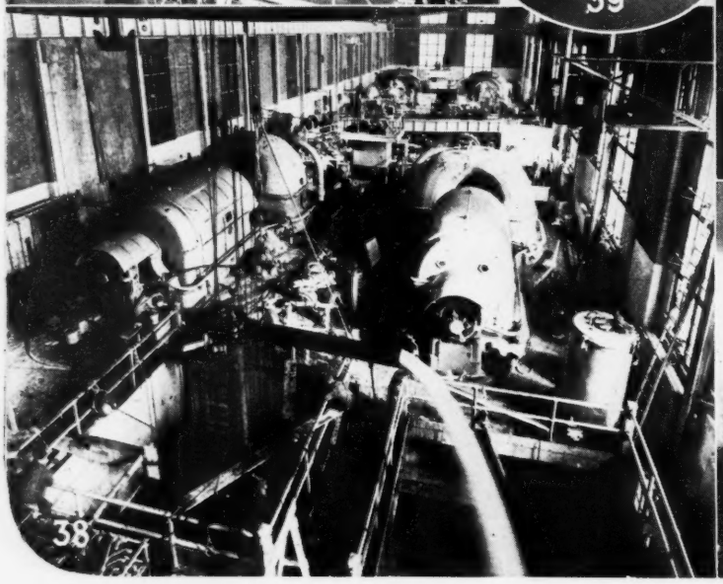
When the flood receded, vacuum driers were made out of two lengths of 14-in. pipe with steam coils inside, piped from the condenser of the first unit back on the line, Sat. evening, Feb. 6. The other unit was back on the line Feb. 10.

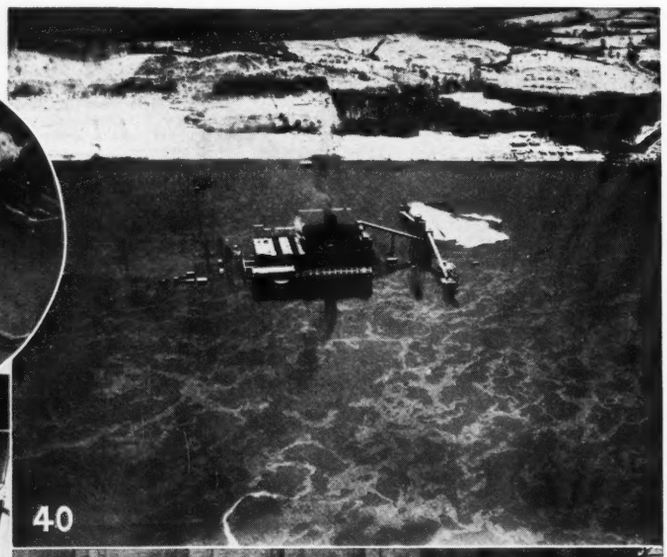
For statistical details on the flood, see *Power* for March, pages 172-174, and for an observer's account of the Louisville flood, see page 228 of this issue.

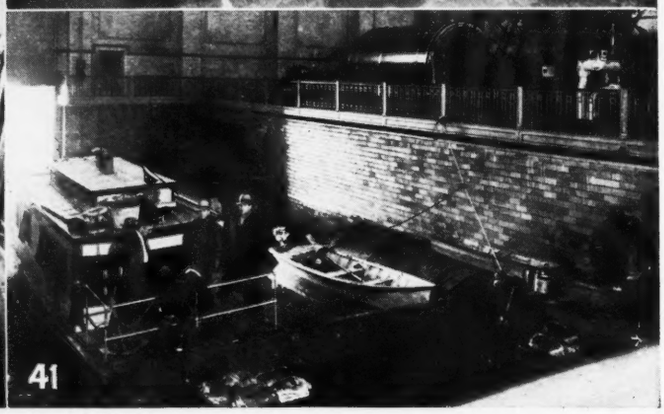
West End (Cincinnati) formed two substations (33) out of four discarded transformers and salvaged contactors. Forty auto batteries provide control voltage (34). A walkway over wired-down coal cars from a C&O coal tipple to the gas-meter house was eventually submerged, to be replaced by a pontoon bridge (37). Condenser pits were checked by diver (39), then pumped out with resurrected condenser vacuum pumps on rafts, using 12-in. spiral-welded pipe and boiler-bunker welded-on flanges for discharge (35). Bulkheading failed to save the new transformers (36). Floods mess up clean turbine rooms (38). Columbia Park was as near Kentucky as Ohio, with gasoline floating on the water into its boiler room (40—M. Parks Watson photo), and boats gave access to the turbine room (41)











Steam Engine Control—II

By F. J. Vonachen

Troy Engine and Machine Co.

This, the second of three articles, applies engine control to stoker, forced- and induced-draft fan, and generator drives. The concluding article will deal with control of refrigerating equipment, compressors and exhausters

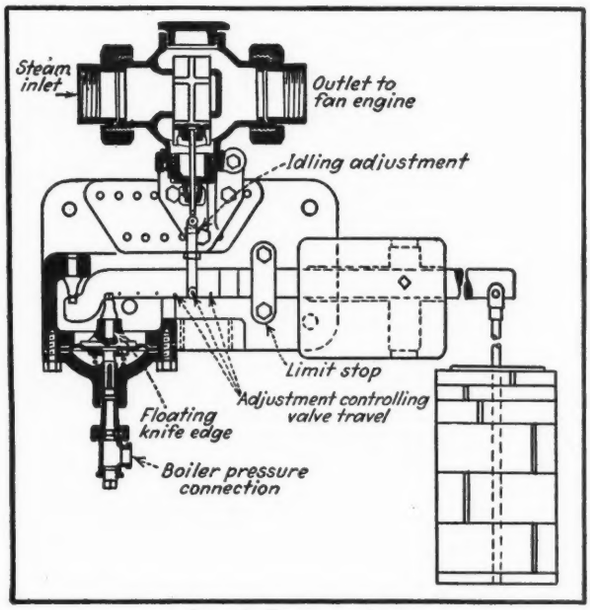
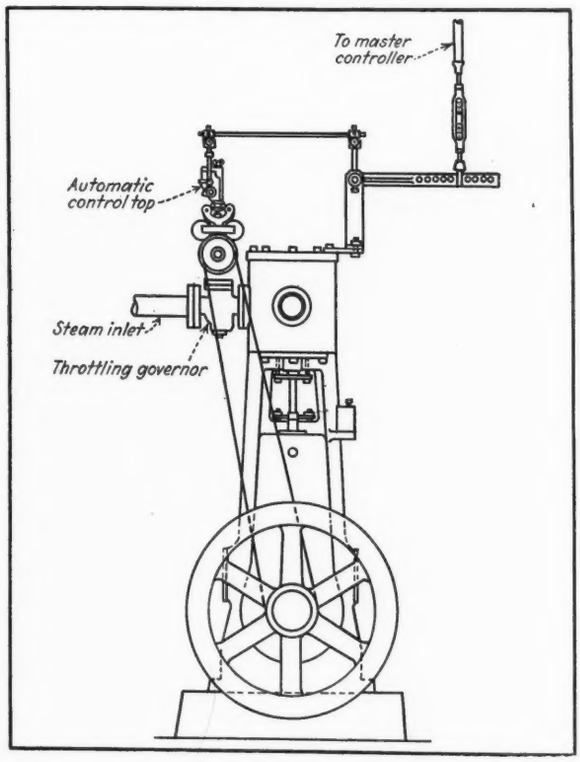


Fig. 10—Engine regulator

Fig. 11—Automatc control top on stoker engine connected to controller

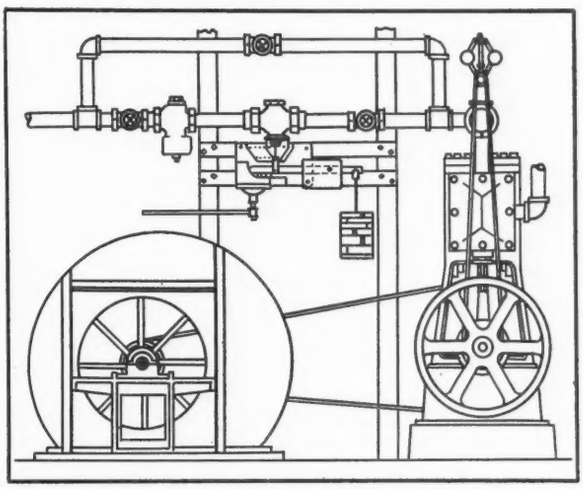


SINCE almost all industries have boiler plants, perhaps the most common application of control is to stokers, dampers, and draft fans. Here, the primary purpose is to maintain high efficiency, uniform furnace conditions, and constant steam pressure with varying steam load. Control must necessarily insure plant safety in the event of failure, must have low maintenance itself as well as control operation to give low plant maintenance, must be stable—free from hunting—and capable of coordinating with the rest of the system.

Boiler control systems consist of: (1) suitable instruments; (2) master controllers or pressure-responsive elements (diaphragm or bellows) which are actuated by reduced or increased steam pressure resulting from variation in steam flow or furnace pressure; (3) regulators which control speed of engines driving stokers and draft fans; and (4) connections from master controllers to regulators.

Stoker and fan engines are usually controlled by drop in steam pressure due to flow. Dampers can be controlled by steam pressure, but more usually by the furnace-pressure controller, which keeps furnace pressure constant and slightly below atmospheric pressure. Draft-fan engines can also be controlled by the furnace-pressure controller. All controls, from the simplest to the most complicated, provide for engine-speed control, since capacity of both fans and stokers varies directly with speed. No detailed description will be given here of instruments or controllers, as these have been fully described in previous articles, and also in the special section on

Fig. 12—Engine regulator applied to fan drive



combustion control, pages 197 to 220 of this issue.

One type of engine regulator for this service, Fig. 1, consists of a diaphragm subjected to pressure on one side and counterbalanced by a weighted beam carried on knife edges and attached to the other side of the diaphragm. Other types are balanced by springs. The beam is connected to the balanced-valve stem by a link, adjusting valve-stem travel for a particular beam movement and to supply correct amount of steam to the engine for idling when the regulator is in a closed position. Fig. 12 shows the regulator connected to a fan engine. The balanced valve controls amount of steam supplied the engine.

The controller is connected to the engine regulators by air, oil, water, or steam pressure; or by mechanical or electrical means. It can be connected to a stoker through a regulator which merely regulates steam supply to the engine, but a mechanical connection to the control top of a flyball-throttling governor, Fig. 11, has definite advantages, as this will keep stoker speed constant for a definite position of the controller, even with widely varying load due to clinker formation, coal wedging in the stoker, etc. There is also less danger of stalling the engine at low speed with suddenly increased load, as the throttling governor valve will open wide quickly to take care of load. This is not so important for fan drive, because load does not fluctuate so rapidly.

This characteristic of the stoker can also be controlled with a tachometer compressor driven by the stoker engine, Fig. 13. Air pressure is applied to one side of a diaphragm valve, steam pressure to be controlled to the other side. If stoker speed should vary because of variation in stoker load, pressure balance on the diaphragm valve is disturbed and this unbalance is transmitted to the engine regulator, which changes steam supply to correct it.

Typical boiler-control installations are shown in the diagrammatic sketches, Figs. 14, 15, 16 and 17. Control can be manual, automatic or a combination. When more than one boiler is being operated, the steam-pressure controller becomes the master controller of all boilers. Other equipment is duplicated.

In addition to the position controls shown, so-called metered control can be used. This consists of additional controls to measure fuel and air and to control engine-driven fans and stokers.

Backpressure governing

In a plant where exhaust steam requirements for heating and processing vary considerably and are not always in synchronism with power demand, and where requirements are low compared to power required, it may be advisable to both buy and generate power. The steam-generating set can be operated in parallel with utility lines and controlled by a spring-loaded, diaphragm-actuated pressure regulator which varies steam supply to the engine to give a constant exhaust backpressure, thereby limiting amount of exhaust to plant requirements, Fig. 18. Only enough power will be developed to supply the required exhaust steam, the balance coming from utility.

With this arrangement, engine speed, frequency and voltage are automatically kept the same as the utility. Consequently, neither engine governor nor

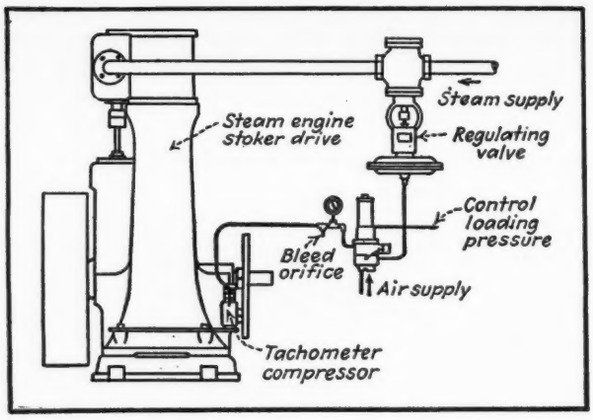


Fig. 13—Tachometer control applied to stoker engine

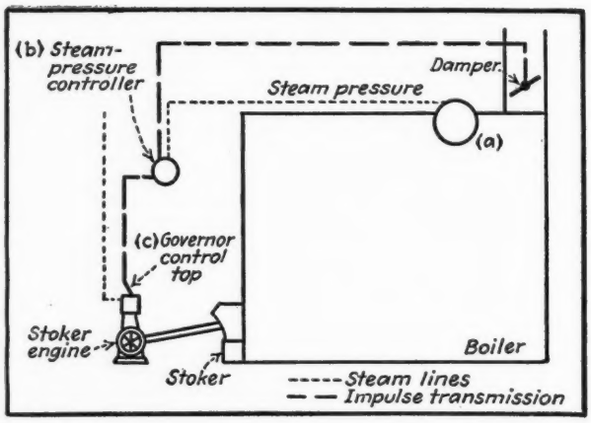


Fig. 14—Engine-driven stoker—natural draft automatic control of fuel and air

When steam requirements decrease, steam pressure at (a) increases. This actuates steam pressure controller (b) which reduces the supply of steam to stoker engine through stoker engine governor control top (c), decreases the stoker engine speed, and the fuel feed rate to the boiler. Steam pressure regulator (b) also closes damper (d) and limits the air to the boiler. When steam requirements increase, the process reverses

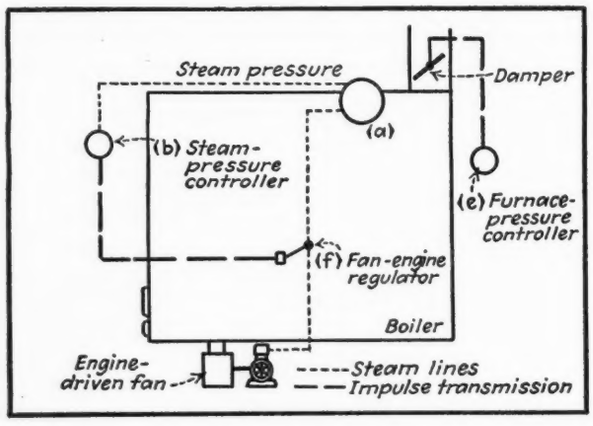


Fig. 15—Hand-fired—forced-draft automatic control of air

When steam requirements decrease, steam pressure at (a) increases. This actuates steam-pressure controller (b), which in turn actuates fan engine regulator (f), which reduces steam supply to the fan engine, fan speed and amount of air. Furnace-pressure controller (e) moves the damper to maintain constant furnace pressure for varying air. The operator should decrease the amount of fuel. When steam requirements increase, the process reverses

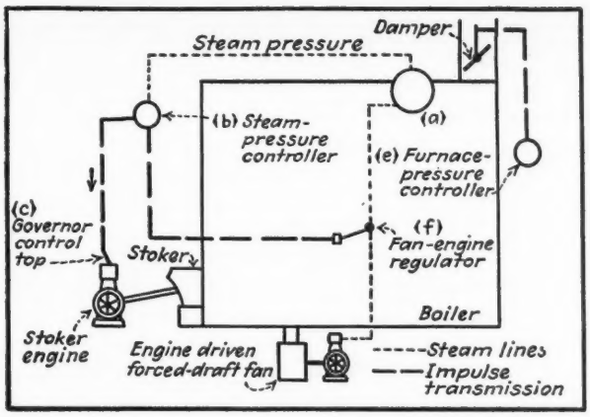


Fig. 16—Engine-driven stoker and forced-draft fan automatic control of fuel and air

When steam requirements decrease, steam pressure at (a) increases. This actuates steam-pressure controller (b) which in turn actuates governor control top (c) to reduce steam supply to the stoker engine, its speed and rate of fuel feed, and also actuates fan-engine regulator (f) to reduce steam supply to the fan engine, its speed and amount of air. Furnace-pressure controller (e) moves the damper to maintain constant furnace pressure for varying air. When steam requirements increase, the process reverses

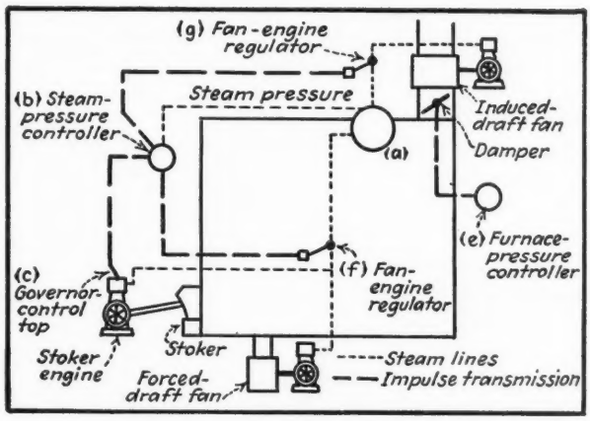


Fig. 17—Engine-driven stoker, forced- and induced-draft fans automatic control of fuel and air

When steam requirements decrease, steam pressure at (a) increases. This actuates steam-pressure controller (b), which in turn actuates governor control top (c) to reduce the steam supply to the stoker engine, its speed and the rate of fuel feed, and also actuates fan-engine regulators (f) and (g) to reduce steam supply to the fan engines, their speed and the amount of both induced and forced draft. Furnace-pressure controller (e) moves the damper to maintain constant furnace pressure for varying air. When steam requirements increase, the process reverses

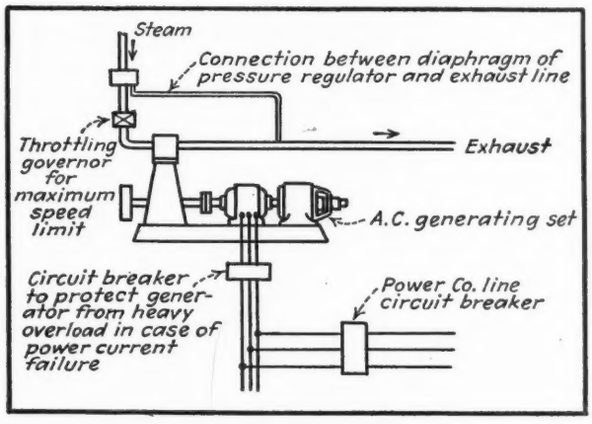

Steam
Connection between diaphragm of pressure regulator and exhaust line
Throttling governor for maximum speed limit
Exhaust
A.C. generating set
Circuit breaker to protect generator from heavy overload in case of power current failure
Power Co. line circuit breaker

Fig. 18—Backpressure control applied to engine-driven generator

voltage regulator are needed. A standard throttling governor should be used, however, as a speed limiting control. Hand-adjustable or variable-eccentric can be set for maximum load, and this cut-off used for all loads. If the variable-eccentric is operated by an electric motor actuated by back-pressure control, amount of steam supplied the engine can be governed by varying engine cut-off, in which case cut-off will be the most economical for each particular load.

Such an arrangement could also be used, for instance, with pumps operating in parallel, some motor-driven and others engine-driven, or both motor and engine could be connected to the same pump.

Diesels in England

DIESEL Engine Users Assn., London, in its annual "Report on Heavy-Oil Engine Working Costs," shows averages taken on 36 English stations, in which 0.654 lb. of fuel oil were used per kw.-hr., and 1,690 b.hp. were run per gal. of lube oil. An average of 20 overseas stations showed approximately same consumption of fuel oil, but with 2,185 b.hp. run per gal. of lube oil.

J. W. Nice of Edmundson's Electricity Corp., Ltd., commented that in the first or second year's life of an engine, wear is usually at the rate of 0.002 to 0.003 in. per 1,000 hr., during which time the liner produced a hardened skin. For long life, this skin should not be disturbed. Wear occurs at the extreme top piston-ring travel, and at 3 in. down is little more than half the top reading, after which wear is gradually reduced until the bottom ring travel is reached, when wear is nil. The main cause of liner wear is running with excessive carbon deposit above the top ring, and by carefully selecting lubricating oils, this deposit can be almost negligible. Minor adjustments and frequent attention to detail pay in the end.

A. C. Johnson of Southland Borough Electricity Dept. mentioned reduction in lubricating costs, partly due to adoption of slotted scraper rings in place of taper rings and partly to chemical cleansing of oil coolers, noting also that jackets and cylinder heads are being acid cleaned instead of sandblasted.

P. P. Navalkar, Burhanpur Electric Supply & Trading Co. (India), related his experience with excessive lubricating-oil consumption and stated that it is possible that high lubricating-oil pressure causes unnecessary consumption. He reduced pressure from 15 to 8 lb. per sq. in., and lube-oil consumption fell considerably. Also intends to add another oil-cooling system, because in summer engine-room temperature goes up to 120 deg. F., and high temperature also makes for high consumption.

D. E. T. Brown, Surat Electricity Co., reported reducing liner wear, but not enough, for in spite of careful treatment of cooling water and lubricating oil, wear averaged 0.003 in. per 1,000 hr. He observed that: (1) running plant load factor has a definite bearing on liner wear. A high average r.p.l.f. results in increased liner wear. (2) Carbonization of lube oil on pistons due to excessive lubrication is also an important contributory cause of liner wear.

How to Align Turbine Drives

By C. C. Hermann

Waterloo, Iowa

PROPER alignment of a steam-turbine-driven machine can best be understood by checking up a machine that has been aligned by a capable mechanic. Go into a power plant where a machine is operating properly. Take with you a straightedge about 12 in. long, an accurately made wedge 12 in. long, $\frac{1}{2}$ in. wide and tapering from $\frac{3}{8}$-in. down to $\frac{1}{16}$ in. See that the machine has been running long enough to be expanded to normal operating position, then stop it.

Referring to Fig. 1 *a*, which shows the coupling between turbine and driven machine, place the straightedge across the coupling top. If the unit is in proper alignment, the straightedge will rest squarely across the rims of both halves of the coupling at any point on its circumference. Fig. 1 *b* shows how the straightedge rests across the coupling when the machine is out of alignment. Now thrust a steel wedge between the coupling faces. Do not force it, but be sure it contacts squarely with both halves. Make a scriber mark at the edge of the rim on the wedge and insert it between the coupling faces diametrically opposite. If the wedge enters to the same point, the unit is properly aligned, Fig. 1 *c*. Fig. 1 *d* shows, somewhat exaggerated, a condition of misalignment.

I am presupposing that coupling halves are of the same diameter, which they should be, and that the coupling has not been mistreated by a careless workman in setting up the unit. If the wedge check shows the coupling to be off slightly, actual condition of the coupling fit can be checked further. Insert the wedge in one side, after removing coupling bolts, and make a mark on the wedge. Now turn one coupling half through 180 deg. and check again. If the wedge enters more or less than it did previously, the coupling is slightly out of alignment with the shaft. The probable fault is either original misalignment of the machine or hammering by some careless workman.

I know of no simpler method to align either new or old machines or to check installed machines of smaller size, such as small pump units, fans, etc. Of course, with large turbines this method is not sufficiently accurate. In such cases, an over-all line should be run through bearing centers.

New Machines

With a new machine, procedure is quite simple and considerable accuracy in alignment is assured. First, place the bedplate on its foundation. It is assumed that a concrete foundation has been prepared of sufficient size and permanency to assure ample support under all parts of the bedplate and for the entire weight of a machine accompanied by some tendency towards vibration in operation. Sometimes this involves cutting through the floor and excavating to firm bearing for a foundation.

It is also assumed that a template has been made of baseplate bolt holes and that foundation bolts have been incorporated in concrete. Fig. 2 shows bolts correctly imbedded in concrete with a piece of pipe encircling them to permit necessary bolt movement when the baseplate is set down. After the baseplate has been started over the bolts, the pipe may be filled with molten lead. Otherwise, the concrete foundation may be constructed with a curb, Fig. 3, which is later filled with cement grout to hold the machine base in place. In either case, however, some cement will run into the ends of foundation-bolting pipe when grout is placed under the machine.

The second step is to drive metal wedges beneath the baseplate until it has been determined perfectly level with a mechanic's level. These wedges should

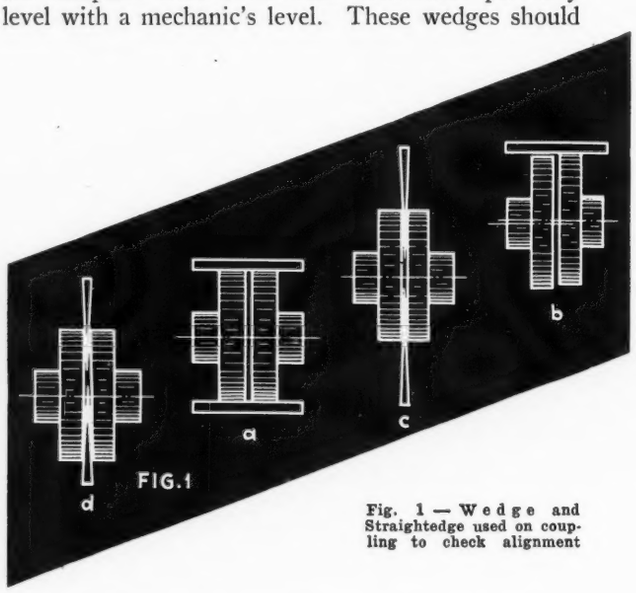


Fig. 1 — Wedge and Straightedge used on coupling to check alignment

be placed near the supporting pads, and with a curb-type foundation, grooves in the curb should be provided for wedges. Leveling, of course, should be done on machined pads on the baseplate. If the machine is received already mounted on the baseplate, it need not be removed.

However, if the machine is separate from the plate, clean off machine pads and place the machine in position. See that dowels are driven in where instructed by the manufacturer before tightening down machine-holding bolts. Seat dowels with a light hammer; never swell a dowel with heavy hammer blows, for such carelessness results in misalignment difficult to trace. Dowels should be inserted by hand and should have sufficient play so that they can be turned with the fingers, otherwise the machine is not seated correctly.

When the machine is seated on the baseplate, check alignment by either the method given previ-

ously or by the tight-wire method. If alignment is off, try to determine why. Perhaps the baseplate was damaged during shipment, in which case no amount of levelling will help. Tap wedges under the baseplate slightly until alignment of the machine is obtained, being careful to keep the machine level. It may be best to place shim stock under the machine feet, and, in some cases, it has been necessary to ream out dowel-pin holes in order to obtain alignment.

It must be emphasized, however, that the machine is now in alignment only when cold; compensation for turbine expansion must be made. If the machine is aligned while cold, it will show high when hot. Obviously, the thing to do is to set the turbine slightly low when cold, but just how much is the question.

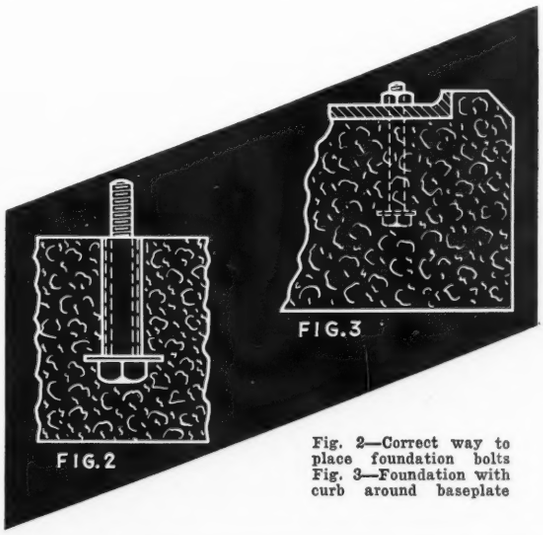


Fig. 2—Correct way to place foundation bolts
Fig. 3—Foundation with curb around baseplate

The height in inches of the machine from the base of bolting pades to center of shaft multiplied by the coefficient of expansion, then by the rise in temperature, and then by 0.7 will determine fairly accurately expansion of the machine and will represent the amount in inches that the turbine should be set low. But it cannot be taken for granted that alignment will be proper when the machine is heated. The turbine should be run for a period, checked again, and adjustment made. Of course, temperature allowance should not be applied to a turbine driving a boiler-feed pump, as in this case the pump is also subjected to a temperature rise. Here, temperature difference should be taken as that between the turbine and pump under normal operation.

Caution must also be taken in getting proper axial clearance between coupling flanges. Units must be set far enough apart so that coupling flanges will not strike together under any circumstances. Usually $\frac{1}{4}$ to $\frac{3}{8}$ in. is sufficient; never more than the larger figure except in larger machines.

I have purposely left mention of grouting to the last, since grout thickness is a very debatable question. There are many special preparations on the market, some of which are very superior to Portland cement and sand mixtures. However, in most cases, I prefer ordinary cement grout. It is lower in cost and, with few exceptions, results are just as good. Use the thinnest grout possible down to a minimum of about $\frac{1}{2}$ in. If grout is thinner than $\frac{1}{2}$ in., it is hard to feed uniformly under the machine. Only rarely need it be thicker than 1 in.

EXHAUST LINES

By E. J. Tangerman

Phil Sprague, president of Hays Corporation, is an inveterate gadget hunter, hence easy prey for corner hawkers. He is quite bald, yet some one of his friends is forever trying to borrow his comb. So now Phil is prepared. On a visit to a comb factory recently, he had a special bald-headed man's comb made up—formed accurately to shape, but without the teeth separated. It combs like a knife blade would.

Incidentally, Hays Corp. has dozens of small screws and parts for instruments, just a nice size to get stuck in every little crevice. So the mechanics have rigged up tiers of muffin tins, one kind of screw per depression. The storage cabinet simply has guide rails onto which the tins can be slid. Hays also has a lot of steel-drawer cabinets for filing literature, cards, etc. It turns out they're quite cheap, being made by Hobart Bros., the welding people, as training for embryo welders in their school.

Arthur D. Little says that the eerie squeak of the windmill, once annihilated by gasoline power, has now returned to haunt the home of its successor. For windmills are being used to protect vast pipeline networks from corrosion. Thousands of miles of such pipelines have been laid for years, under conditions ideal for corrosion, with attendant leakage and heavy maintenance costs. It seems that iron pipe in contact with moist earth becomes an anode from which iron ions go off into the soil, at a rate of 20 lb. a year if one ampere of current passes. But the windmill stops all that, because it generates a small current, conducted to the positive pole of a pile of scrap iron buried near the pipeline and the negative poles strung along the pipelines. Rock salt is dumped into the earth between scrap and line to increase conductivity. Then the current proceeds to electrolyze the scrap iron and to form a protective coating of hydrogen on the pipe!

Down at Baldwin Locomotive, I saw them building big Mallet-type locomotives to run backwards. The cab is where it ought to be, but the smokebox and stack are connected to the tender. Of course, control levers are put in a stand in front of the operator, and what should be the back of the cab is glassed shut. The bell comes down off the smokebox and goes under the cab with the headlight. Southern Pacific uses these huge 2-8-2-8 units to haul freight. They told me at Baldwin that the conventional locomotive is likely to get stuck in snow under a snowshed and almost suffocate both the engineer and the fire. But this way the stack is behind the cab, and both the fire and the engineer benefit.

Silica aerogel, really a jellified oxide of various metals, is claimed to be quite a good insulator. It is an extremely light mass of powdery soft and compressible material weighing four to ten lb. per cu.ft. Dry, it works well for refrigeration insulation; wet, it can be used to bulk thin oils into greases.

At New Castle, Ind., load has built up so steadily on the municipal diesel plant that they need a new unit. Though all their older units are De La Vergnes operating around 225 to 300 r.p.m., the new one will turn at around 800, an 8-cyl., 1,000-hp. unit. But the new one couldn't be delivered immediately, so De La Vergne sent out a 6-cyl. 300-hp. 720-r.p.m. unit as a stop-gap. In spite of its tripled speed, they like it so well at New Castle they think they may keep it.

A Laundry Power Plant Comes of Age

By Chas. H. Herr

Chief Engineer,
Excelsior-Leader Laundry, St. Louis, Mo.

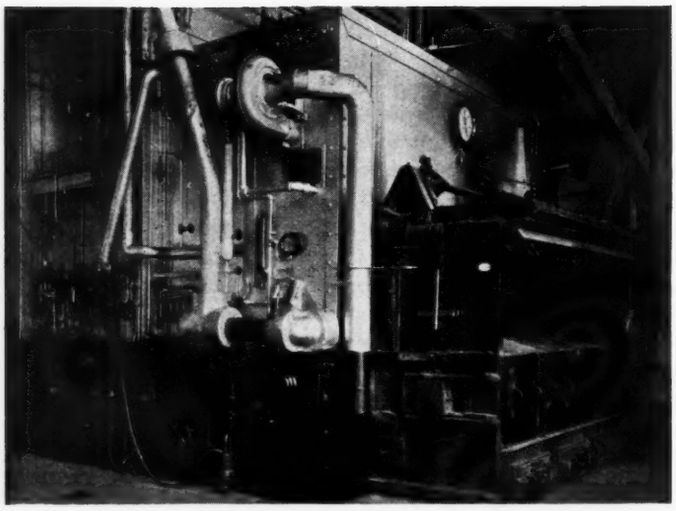


Fig. 1—One of the straight-tube 5340-sq. ft. Murray boilers

Intelligent engineering leading up to complete modernization enables power-service facilities of growing laundry to keep pace with business expansion

THE Excelsior-Leader Laundry power plant, erected in 1922, was equipped with a 2,860-sq.ft. Heine water-tube boiler with a hand stoker and two Harrisburg engine-generator sets, 40 and 75 kw. Laundry machinery was individually driven by d.c. motors.

An additional 2,860-sq.ft. boiler was installed in 1923, and in 1924 a used 350-kw. Skinner Unaflow generating unit. Between 1924 and 1926, boiler capacity was increased by enlarging grate area. In 1926, undergrate blowers were installed to handle the growing steam load. At this time a 300-kw. G.E. turbine-generator replaced the 75-kw. engine-generator set. Flowmeters installed in 1927 so improved boiler room operation that further capacity was not needed until 1929. In 1927, however, it was decided to modernize existing boiler equipment and incorporate it in a complete new power plant. This was placed in operation in 1929.

Normal winter steam load in the old plant was about 33,000 lb. per hr., with peaks of 36,000 to 42,000 lb. Two 5,340-sq.ft. Murray water-tube boilers were installed, Fig. 1. By using one new boiler and operating the old boilers at 150 to 175% rating, it is possible at all times to remove at least one unit from service for repairs and general maintenance.

The new boilers are of the straight-tube type, 16 tubes wide and 18 tubes high, with two 42-in. horizontal drums, and are designed for 250-lb. pressure. Operating pressure, however, is only 135 lb. Vertical baffling is used, and the front header is set 15 ft. from the floor. This type of boiler was chosen for ease of maintenance and greater water capacity.

Both units are equipped with Illinois chain-grate stokers 9 ft. wide by 15 ft. centers, designed to operate at 250% rating with 10,000-B.t.u. coal. Drive is by variable-speed d.c. motors, 350 to 1,200 r.p.m. The two 18,000-c.f.m. Buffalo Forge forced-draft fans are driven by variable-speed (850 to 1,150 r.p.m.) ball bearing G.E. d.c. motors. Double-throw switches are provided so that the armature can be put on ½ voltage, giving a low speed range of 450 to 600 r.p.m. Fans on the boiler-room floor discharge into a concrete duct under the boiler-room floor. Dampers are arranged so that both fans can be used together for both boilers, or either fan for either boiler.

A Defender draft regulator controls admission air and is set to hold about 0.05-in. furnace draft. A Defender compensated master regulator, with additional equipment built in our shop, controls uptake damper and stoker speed, also automatically controls over-fire air. Each boiler is equipped with Golden-Anderson non-return valves, American safety valves, Yarnall-Waring high-and-low water alarm-type water columns with inclined gages, Yarnall-Waring quarter-turn and blowoff valves, and Bayer soot blowers.

Boiler feedwater containing 20 to 25% zeolite-softened makeup is heated in a deaerating heater and then pumped to the boilers by one of two 100-g.p.m., Dayton-Dowd, centrifugal pumps, driven by 30-hp. Westinghouse motors. Duplicate feed lines are provided for each unit, one arranged for hand feeding, the other controlled by a Bailey feedwater regulator. A Fisher excess-pressure regulator maintains a 20- to 25-lb. differential across the feedwater regulator.

Boilers are equipped with Bailey boiler meters, indicating and recording steam flow, air flow, and flue-gas temperature. Feedwater- and blowoff-tank temperatures are measured with recording thermometers.

A 220-ft. high, 8-ft. top Wiederholdt stack, of special tile filled with cement, steel-reinforced, serves the new boilers.

Coal trucked to the plant is dumped into a concrete hopper in a public alley adjoining the plant. The opening is safeguarded by a "grizzly" and a motor-operated steel door. A Jeffrey bucket elevator driven by a 3-hp. G.E. motor receives coal

from a reciprocating-plate feeder underneath the hopper and deposits it into a scraper conveyor emptying at four points into a 200-ton suspended bunker. A 3-hp. G.E. motor drives the scraper. Electrical interlocks insure that the scraper is running before the elevator. The 42x20-ft. coal bunker is built of steel plate covered with a bitumastic material and lined with 1-in. tongue-and-groove tile set in cement mortar.

A Jeffrey 2,000-lb. motor-driven weigh larry receives coal from four 18x18-in. gates and delivers it to the stoker hoppers. Ashes, raked by hand from ash pits to a Nuveyor steam-jet vacuum conveying system, are delivered dry to a 25-ton ash receiver, from which they are removed by trucks.

Behind each boiler is a 200,000- gal. Permutit water softener and a foundation for a duplicate future unit. In the old section are 50,000-, 75,000- and 100,000-gal. Permutit softeners, ratings based on the number of gallons of 9-grain water softened between regenerations. Two concrete tanks, 10x17x9 ft., in the ash basement in front of boilers, make salt brine. After being pumped to an overhead calibrated tank by a 50-g.p.m. Dayton-Dowd pump, brine flows by gravity to softeners requiring regeneration.

Two 30,000-gal. cypress water tanks on the boiler-room roof afford storage for hot and cold soft water. All hot water used in the laundry comes from this tank, which acts as an accumulator and smoothes out irregularities in steam demand caused by variation in hot-water demand from 20,000 to 60,000 gal. per hr. With the tank it is possible to heat water at an even rate.

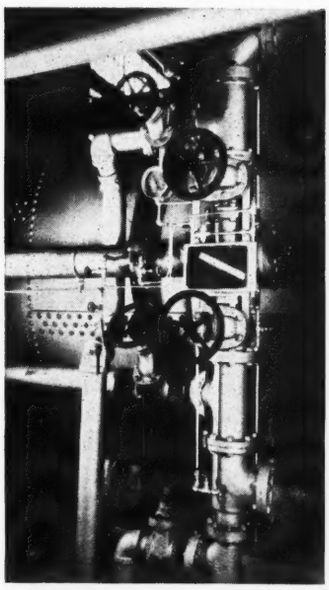


Fig. 2—Control equipment for softeners

From the cold-water tank, water is piped to another set of tanks at a lower elevation. A thermostatic regulator controls a hot-water admission valve in this piping so that temperature in these tanks will not fall below 75 deg. nor become greater than normal summer water temperature. Water level is controlled by a low-pressure compensating regulator arranged so that the water line is about 10 ft. lower at full valve opening than when it is nearly closed, thus smoothing out variations caused by sudden demands for larger quantities of water.

A 12-in. city-water line metered by two 8-in. meters in parallel takes care of water demand. An emergency 6-in. Chas. S. Lewis booster pump is provided.

Recording thermometers show the temperature of hot water and tempered cold water. An indicating thermometer is used in the hot-water line to the roof tank. Bailey fluid meters indicate and record water flow in the city-water line and the lines to each of four water softeners in the plant.

A 3-unit motor-generator set, replacing the 40-kw. engine-generator, is used for emergency at night and on Sundays, and for starting stokers and fans in the morning before main generators are on the line. The motor-generator consists of a 60-hp. a.c. motor and two 20-kw. d.c. generators connected to furnish 110- and 220-volt current. By connecting these generators similarly to the old Edison 3-wire system, a greater unbalance can be handled than with a regular 3-wire generator.

Operating Results

The plant has given little trouble, although difficulty was experienced at first in properly burning low-grade fuel, $1\frac{1}{4}$-in. screenings of 9,500 to 10,000 B.t.u. per lb. Incoming coal ignited improperly, causing the furnace to have a larger amount of fuel than load justified. Eventually this fuel would become thoroughly ignited, increasing pressure and closing dampers, which in turn increased CO_2 and the furnace temperature to such a point that dampers remained closed until excess fuel burned up. Then, when pressure loss demanded more fuel, time lag required caused a very disagreeable hunting action and excessive steam-pressure variation. This was partly overcome by manually opening the regulator according to load, and this, in turn, was improved by automatically setting the damper for load and trimming final setting according to steam pressure. Stoker speed was controlled in the same manner.

We did not get desired results, however, until we were able to control over-fire air automatically. Originally, the furnace was equipped with a fan, which blew air through arch openings, but which

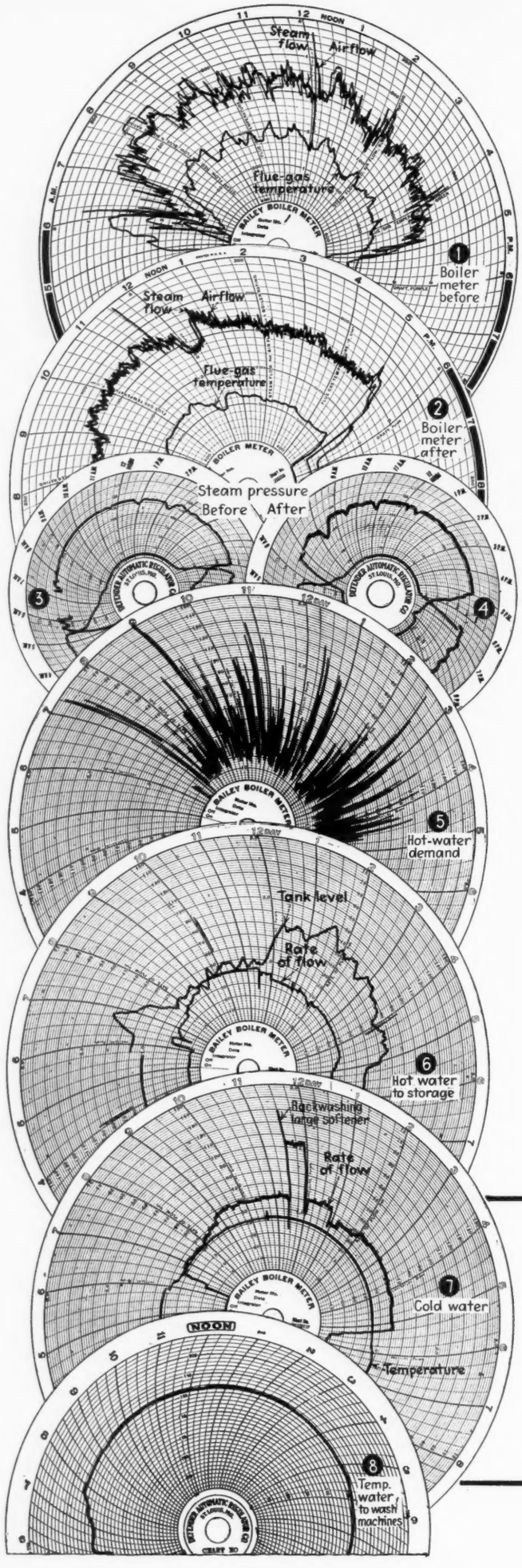
CHARLES H. HERR always wanted to be an engineer. Born in St. Louis on May 5, 1888, he went to work as an office boy for the brewmaster of a large St. Louis brewery at 13, after graduating from grammer school. There, well-kept machinery fascinated him—and still does.

So the following year he went to work as a helper in the electrical gang at American Car & Foundry's local plant, and two years later at 16, joined Brown Shoe Co., expecting to be put to work as a wireman's helper. Instead, he was given a helper and told he was a wireman, and after holding that job during erection of a large shoe factory, was made maintenance man. After holding various positions in the mechanical and electrical departments, Herr obtained his operating engineer's license at 21. With Brown Shoe Co., he became assistant chief engineer, his activities extending over 11 plants scattered over a radius of 300 miles from St. Louis.

Next job was with Reliance Elevator Co. in St. Louis, as organizer of a repair department, but lack of capital made the elevator company non-existent and led Mr. Herr back to electricity—he joined the sales force of C. J. & F. E. Briner Electrical Co.

In 1924, he was appointed chief engineer of the Federal Reserve Bank building in St. Louis, then under construction. There he supervised installation of all mechanical and electrical equipment, and after the building was completed, was in charge of mechanical and electrical departments as well as building operation and maintenance. In his present position, he is in charge of all mechanical, electrical and automotive equipment and building maintenance for the Excelsior-Leader Laundry.

As a past president and a member of their Educational Committee for 15 years, St. Louis N.A.P.E. members know him well. At present, Mr. Herr is treasurer of the local association and treasurer of the Convention Committee for N.A.P.E., whose 1937 convention is being held in St. Louis. He is also a Mason and a member of the Engineer's Club of St. Louis.



at higher ratings was not effective in creating turbulence. Later, two steam jets were installed to supplement air jets, and some improvement was noted.

Then, we installed a steam jet in each side wall, the intention being to blow flame to the front and aid ignition, which it did to such an extent that we were unable to maintain ignition nose on the arch. To secure better control, jets were re-installed at the furnace rear, and to our surprise created very effective turbulence. These jets do not induce any air into the furnace, but drive lean gas forward, and by displacement cause flames and rich gas to draw to the rear and turn downward to become thoroughly mixed. Figs. 4 and 5 indicate gas flow with and without these jets, which use about half the steam required to operate the boiler as originally installed and which require less than 0.5% of steam generated. This jet action allowed us to discontinue over-fire air admitted at the front, and we now automatically control over-fire air and admit it through the ashpit.

Air Control

Automatic control of over-fire air admits more air as pressure rises, and decreases it as pressure lowers. The tendency when a very large and rapid load change occurs, is to slightly decrease CO_2, and there may be a slight increase on rising load, but for the most part, CO_2 remains constant. A further advantage is the ability to carry longer fires for faster response to load changes.

We carry loads up to 240% and as low as 80% in normal operation, with 13 to 14% CO_2 on loads above 100%, and have no difficulty in getting 12% CO_2 on 75% to 80% ratings without excessive unburned fuel. On test, we have secured 16% CO_2 with no CO and no smoke, but for continuous operation, 14% CO_2 represents the maximum because of refractory maintenance.

During a year, approximately 60,000,000 lb. of steam from and at 212 deg. were generated with 4,272 tons of coal, an average evaporation of 6.8 lb. of steam per lb. of coal. Coal included that used for banking and raising steam, which sometimes amounts to ⅓ of coal used per day. On checks made after the boiler is underway, evaporation of 7.8 lb. of steam per lb. of coal have been shown in daily operation. The grade coal we use costs about $1.60 per ton, delivered, a cost of $0.12 per 1,000 lb. of steam.

After a period of operation, pitting was noticed

Chart 1—Boiler meter chart before changes in combustion control. Note periodic high and low air flow in forenoon. Chart 2 More recent chart, showing how close air and steam pens coincide with present control. Chart 3—Steam-pressure recording chart, covering same period as Chart 1. Chart 4—Steam-pressure chart for period of Chart 2. Chart 5—Flowmeter chart, showing normal great variation in hot-water demand. Chart 6—Flowmeter chart, showing steady flow of water being heated in spite of demand of Chart 5. Water-tank level gives operator trend of demand and is made by using regular temperature-indicator mechanism with proper mercury leg to balance pressure. Chart 7—Flowmeter chart from main cold-water line, indicating rate of flow and temperature. Note heavy flow at 11:30 caused by backwashing large softener. Chart 8—Typical temperature chart on hot-water line leading to wash machines. Note slow drop of temperature from 5 P. M. to 6 A. M. due to cooling in line with no circulation. Charts 2, 4, 6, 7 and 8 are for same day

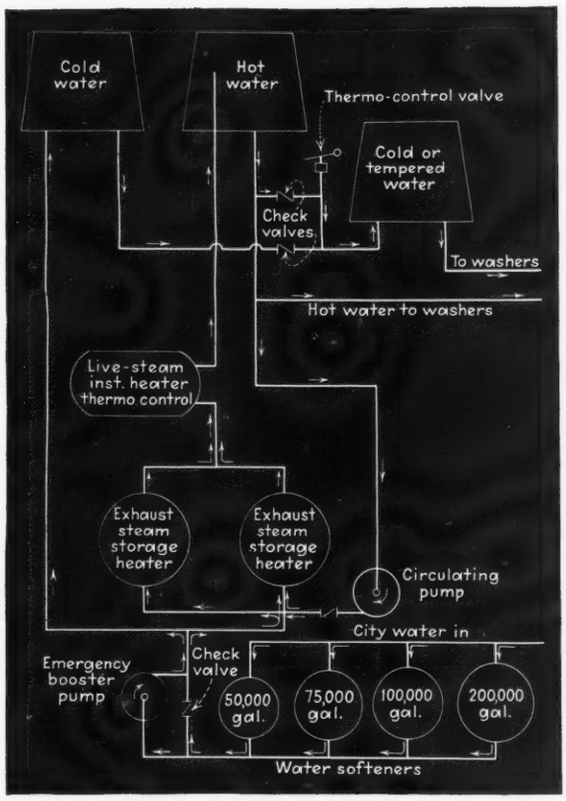


Fig. 3—Water flow in laundry

in boiler drums, although feedwater was deaerated and proper alkalinity maintained with chemical treatment. Principal cause was filling boiler at night with water containing a large per cent of O_2, as the deaerator is out of service at night for lack of steam. This was remedied by substituting sodium sulphite for the boiler compound we were using. By maintaining a concentration of 50 to 60 p.p.m., free oxygen was absorbed; no further trouble with pitting has been noticed for the last two years.

One of two generating units is always sufficient to carry load. All exhaust steam is used for heating process water, the engine or turbine acting as a reducing valve and generating current as a byproduct. Approximately 400,000 kw.-hr. are generated during a year, and 30,000 kw.-hr. purchased.

During the past year, 62,000,000 gal. of water were softened from an average of 6 grains to approximately 0 hardness, and of this amount 35,000,000 gal. were heated to 165 deg. from temperatures ranging from 35 deg. in winter to 85 deg. in summer. When water of higher temperature is needed, it is heated directly by 30-lb. steam supplied to washers. Hook-up of softeners and heaters is shown in Fig. 3.

Charts

Accompanying flowmeter and thermometer charts show how well we have been able to smooth out varying demands and permit softeners, heaters and boilers to operate at comparatively steady loads.

Softeners are run to exhaustion before regeneration, and instead of the usual water meter, we use an indicating flowmeter. As city water pressure does not vary greatly, this permits the operator to quickly adjust control valves to rate of flow desired, regardless of whether he is delivering water to the system, rinsing or backwashing. The flowmeter also allows us to dispense with usual automatic flow controls. Softeners are opened once a year and any necessary repairs made. All tanks and uncovered piping are given a coat of aluminum paint once a year, which practically eliminates external corrosion.

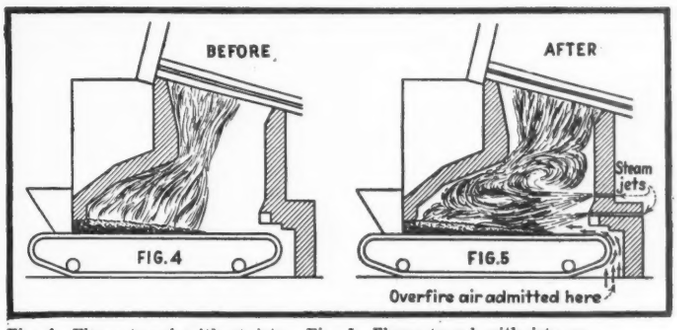


Fig. 4—Flame travel without jets. Fig. 5—Flame travel with jets on

Heat reclaimers for recovering heat from waste water are not used. Estimates indicate that the cost, due to physical necessities of an installation in our plant, combined with comparatively low cost of coal, makes it an uneconomical proposition.

Maintenance By Inspection

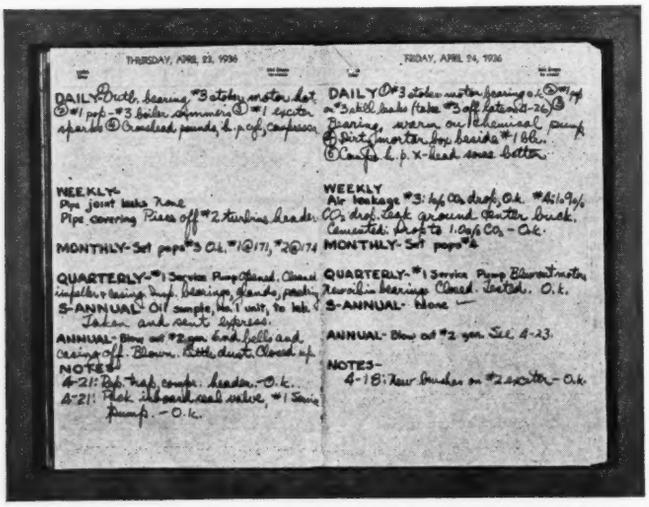
R. H. Sogard
Superintendent of Buildings
The University of Missouri

WE HAVE ALL heard so often those essentials of economical steam and electric generation, such as minimum excess air, reduction of air leakage, complete combustion, correct boiler and prime mover loading, minimum absolute exhaust pressure, etc., that they automatically come to mind when thinking of economy improvement. Even before economy, however, comes continuity and its attainment depends on good maintenance.

Satisfactory and low-cost maintenance of plant equipment is attained by anticipatory action that holds to a minimum any damage beyond basic,

inevitable wear and tear. This advance action is based on information obtainable in only one way—*systematic inspection.*

Frequency and extent of inspection differs with various pieces of equipment, as indicated by past experience and time required to make inspections. Whatever the frequency, inspections should be scheduled regularly and executed as unfailingly as payment of a life insurance premium. A convenient means of scheduling is to use a 6x9-in. date book with a page for each day, and actually fill out schedules a year in advance. Daily points need not be entered each day, as their frequency of occurrence soon fixes them in mind. They should be listed at some place in the book, however, to be available. But weekly, monthly, quarterly, semi-annual and annual items should actually be entered in advance, so that mere turning of pages day by


THURSDAY, APRIL 23, 1936

DAILY- Batt. bearing #3 stoker motor hot ③#1 pop.-#3 boiler Hammers ③#1 ejector sparks ⑤ Crosshead pounds, h. p. of compressor

WEEKLY-
Pipe joint leaks None
Pipe covering Pieces off #2 turbine heads.

MONTHLY- Set pops #3 Ok. #1@171, #2@174

QUARTERLY- #1 Service Pump Opened. Cleaned impeller, casing, wear rings, bearings, glands, packing

S-ANNUAL- Oil samples, No 1 unit, to lab. Taken and sent Express.

ANNUAL- Blow out #2 gen. end bells and casing off. Blown. Bottle dust. Closed up.

NOTES-
4-21: Bot. trap, comp. header.-O.k.
4-21: Plat. ilsboard seal valve, #1 Service Pump.-O.k.

FRIDAY, APRIL 24, 1936

DAILY- #3 stoker motor bearing a.[illegible] #3 skill leaks (take #3 off later at 2-26) ⑤ Bearing, worm on chemical pump ⑤ First quarter log, beside #186. ⑤ Comp. h. p. X-head some better.

WEEKLY
Air leakage #3: 1½% CO₂ drop, Ok. #4: 1½% CO₂ drop. Leak ground. Center break. Concrete: Drop to 1.0% CO₂ - Ok.

MONTHLY- Set pops #4

QUARTERLY- #1 Service Pump Blew out motor. Re-oiled bearings. Closed. Tested. O.k.

S-ANNUAL- None

ANNUAL- Blow out #2 gen. See 4-23.

NOTES-
4-18: Rear bushes on #2 stoker - Ok.

A simple and convenient way to keep an inspection schedule

day announces the needs. These less frequent inspections should be staggered throughout the year, of course, to avoid congestion of work at any one time.

A suggested inspection schedule, substantially that used at the University of Missouri, follows:

Daily Inspection

1. Coal handling equipment
2. Boiler room coal scales
3. Stokers and stoker motors (or mills and feeders) externally
4. Furnace brickwork (as visible through doors, etc.)
5. Dampers and controls
6. Pop valves for leakage
7. Blowdown valves
8. Traps
9. Boiler room instruments (apparent functioning)
10. Motor and pump bearings
11. Prime movers—unusual sounds or vibration
12. Prime movers—instruments
13. Prime movers—oil system and oil condition
14. Prime movers—auxiliary equipment
15. Prime movers—trip-throttle valve, freedom of action
16. Generators—heating, noise, bearings
17. Exciters—heating, sparking, bearings
18. Electrical instruments (apparent functioning)
19. Air compressor—valve action, heating, bearings
20. Cooling towers, ponds or intakes
21. Feedwater-treating equipment
22. Plant cleanliness
23. Grounds

Weekly Inspection

1. All valve packings
2. All pump packings
3. Leaks at pipe flanges and joints
4. Leaks around manholes and handholes
5. Air leakage into settings and breeching
6. Condition of pipe covering
7. Blowing out open electrical machinery
8. Checking flowmeters for zero
9. Ash-handling equipment
10. Coal-handling equipment

Monthly Inspection

1. Pop-valve settings
2. Pressure-gage settings
3. Boiler furnaces from inside
4. Stokers, pulverizers, fans and feeders internally
5. Overspeed trips and governors on prime movers
6. Looseness of engine connecting rods, valve gear, etc.
7. Cleaning air receiver with lye and hot water
8. Tools and supplies
9. Station building

Quarterly Inspection

1. Internal condition of all pumps (except deep well)
2. Pump and motor bearings
3. Testing steam-temperature instruments
4. Testing electrical instruments
5. Electrical leads, cables, bus fixtures, etc.
6. Condition of breakers, switches, disconnects

Semi-Annual Inspection

1. Internal condition of boilers
2. Cleaning oil coolers
3. Cleaning air compressor intercooler
4. Laboratory oil tests (lubricating oil)

Annual Inspection

1. Internal condition of prime movers
2. Blowing out closed main generators
3. Testing and renewing insulating oil
4. Pulling deep well pumps

The number of operating hours in any one period of course influences frequency of inspection. When inspection is done by a competent person, it can be so systematized that practically all daily and weekly items can be covered rapidly. By knowing what to look for and how everything should be, it becomes a matter of a very short time (if all is well) at each point: observing, feeling, listening.

On less frequent items, much more time is involved, as inspection then requires testing, adjusting and more or less dismantling and reassembling. This preventive work is considerably less expensive and disruptive to plant output, however, than doing maintenance work only when something breaks down.

Next in importance to scheduled inspections are maintenance records. In a small or medium sized plant, such records may consist simply of 5x8- or 6x9-in. cards in a file box. One card for each piece of equipment is filed alphabetically, and on the cards are entered dated notes telling of internal inspections, conditions found, parts replaced, hours of operation, pop-valve and overspeed settings, clearances, oil testing and instrument adjustments.

No maintenance man wants to do unnecessary paper work. But if a few minutes a day checking off scheduled inspections will insure covering all points regularly and if a few more minutes entering notes on cards will tell him several months hence how he found things and then how he left them, his mind will be much more at ease. The treacherous human memory may forget to act, but time and deterioration are infallible.

COMBUSTION CONTROL

THIS 24-PAGE SPECIAL section, *Power's* twelfth, is devoted exclusively to combustion control. The need is obvious; here is an important branch of power technique never before summarized comprehensively under a single cover. It involves matters of great dollars-and-cents importance to plant owners and a variety of equipment still unfamiliar to many engineers.

All power engineers, of course, understand the general purpose of combustion control, yet few have carefully studied the various systems now available in the American market. This section will make it easier for them to catch up with today's practice.

Before we plunge into the mechanical details, a brief summary of the arguments for combustion control in general will be in order. Whether control is by hand or by machine, two things are required:

1. Adjustment of fuel-burning rate to maintain constant steam pressure.

2. Adjustment of air supply to rate of fuel burning for the highest efficiency consistent with furnace and fuel limitations.

Requirement 1 means that the fuel-burning rate must be kept practically in step with steam demand. Liquid, gaseous or pulverized fuels burn as they are fired, with little "flywheel effect", so their firing rate must parallel the steam load. With stokers, on the other hand, the air-flow rate, rather than firing rate, determines the rate of burning, and must fluctuate moment by moment with steam load. The coal-feed rate must vary in such a way that the mass of coal on the stoker remains practically constant.

Historically, the control of air and fuel is a job for a man with his hands on controls and his eyes on instruments. His performance changes from day to day and from minute to minute. At best, with extraordinary skill and close attention, he closely approaches the performance of the machine, but never holds it. In day-by-day operation, with other demands on his time and attention, a good man may easily fall from 3 to 5% below the efficiency obtainable with machine control.

The primary objectives of automatic control are lower fuel cost and more uniform steam pressure. To these might be added lower labor cost. In general, however, it is not so much a question of reducing labor costs as of releasing brains from routine operation for creative work. Every practical man knows what that means in terms of costs.

In more detail, the advantages of automatic control are many: It is more sensitive to operating requirements than the most skilled human attendant; it starts correcting before conditions get out-of-hand; it stays on the job every instant, whereas even the best of men must turn away now and then.

The furnace, and to some extent the boiler, are protected by the more uniform conditions and by the smaller fluctuations of steam pressure and furnace temperature. More uniform pressure improves turbine-room efficiency and protects the quality of processed products. The safety valves pop less frequently when automatic control watches the gage. With high pressures, particularly, this saves many maintenance dollars. Many of the large high-pressure boilers, with small water storage and high combustion rates, are so sensitive that operation would be practically impossible without automatic control.

Some modern boilers are so large that remote control must, in any case, be provided for their auxiliaries. This means paying for motors, push-buttons, cable, conduit and power-control units. Here most of the investment has been made in any case, and it is simply common sense to make the system completely automatic. With new boiler plants, the combustion-control system should be a coordinated part of the original design—not something tacked on after operation starts.

The treatment of combustion control in the pages that follow is strictly practical. The reader, we assume, wants the brass-tacks of how the control job is done and what equipment is commercially available. He wants to know the elements of each system, how they look inside and out—exactly how they work and why. Fortunately the number of systems is not too great for this presentation by name and type. Each, in turn, is described and explained. The inquiring reader can compare the operating features of the various systems. He can also prepare himself, to a considerable extent, for the intelligent operation of a system already selected or favored.

Elements of Combustion Control

• Automatic combustion control is generally accepted as an essential part of every worthwhile boiler plant. This control equipment is no longer confined to large high-pressure plants, but is now available for small and medium-size installations at a price that makes its installation highly economical. A wide variety of these controls have been developed, older ones have been improved, and new systems perfected to meet the many combustion problems of central stations and industrial plants. To present a composite picture of modern automatic combustion - control systems, ten are here described.

As the term automatic combustion control is now generally understood it applies to a grouping of air-flow and fuel-feed equipment under the control of a master from which a single boiler or a group of boilers may be controlled. On all systems the master is connected to the steam header. Pressure in the boiler drum is maintained constant, and the change in steam pressure between the boiler drum and header, with change in load, is used as the initial impulse to tell the master that a change is required in the combustion rate, and how much. Normally steam-header pressure is allowed to vary about 1% over the boiler operating range, but in some systems the master is compensated to maintain practically constant pressure.

In most systems as now developed, master impulses are transmitted to fuel and air-volume regulators either by air or electrically, some of the various types being shown diagramatically in Figs. 1 to 4. Air pressure used in these systems may vary from a few inches of water to 100 lb. or more, depending upon whether air is used for master loading impulses alone, or for transmitting the impulses and operating the power units. Some systems use electrical master impulses and air or hydraulically operated power units. Still others employ low-pressure air master impulses in combination with electrically operated power units.

Fig. 1 shows a master that uses air as the transmission medium between it and fuel and air regulators. Air at 5-lb. pressure is admitted to chamber A through the throttle valve, pressure in chamber A being

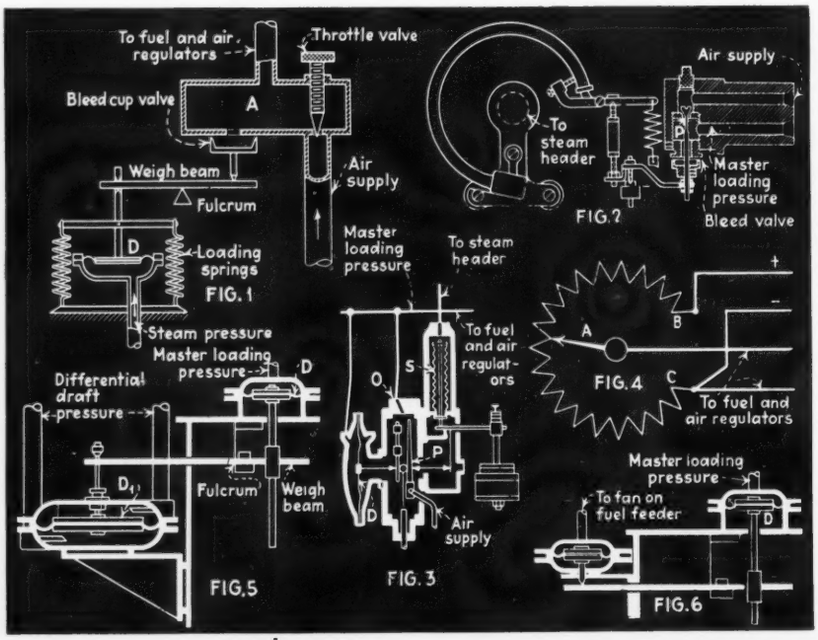


Fig. 1—Master controller using spring-loaded diaphragm and bleed valve to send pressure impulse to fuel and air controllers. Fig. 2—Bourdon-tube-operated bleed and throttle valve make up this master controller. Fig. 3—Air-jet pipe discharging into a nozzle produces master loading presure. Fig. 4—Diagram of a potentiometer operated by master regulator to control fuel-feed and air flow. Fig. 5—Master-loading and draft connections for air-flow regulator. Fig. 6—Master-loading and fuel-feed connections for fuel-feed regulator

determined by position of the cup bleed valve connected to spring-loaded diaphragm D, under which steam header pressure is applied. If header pressure drops, indicating an increase in demand for heat, D moves down slightly, causing the cup valve to reduce its opening and raise the air-loading impulse to the fuel and air regulators. An increase in steam pressure produces an opposite effect to slow down the combustion process.

A bleed valve controlled by a Bourdon tube as part of a master controller is shown in Fig. 2. A decrease in steam pressure allows the Bourdon tube to contract and lift the bleed valve slightly. This will admit more air through port P from the supply to the master-pressure chamber. The bleed valve will close slightly and reduce the air flow from the master-pressure chamber, consequently this pressure will rise. An increase in steam pressure, indicating a decrease in steam demand, will have the opposite effect, so that the master pressure impulse increases and decreases inversely as steam pressure changes.

In the master Fig. 3, air under pressure discharges from a jet pipe P toward an orifice O connected to the master pressure loading line. When the jet pipe is pointed directly into the orifice master pressure is at a maximum and decreases as it is moved away, position of the jet pipe being controlled by steam header pressure acting on the sylphon S. This regulator is stabilized by master pressure acting on diaphragm D.

In a combustion-control system that transmits master impulses electrically, the master regulator moves the arm of a potentiometer, Fig. 4. When arm A is at B, the master loading voltage is equal to that of the supply, and when at C the master voltage is zero. From this it is evident that as the master regulator

moves the potentiometer arm, corresponding changes are made in the master loading voltage to the fuel-feed and air-flow regulators.

How master loading pressure is applied to the fuel-feed and air-flow regulators will depend upon the system. There are as many different ways as there are systems, but they are all designed to accomplish the same end—that is, to vary the fuel and air to the furnace so as to maintain practically constant steam pressure and burn the fuel at high efficiency. Fig. 5 shows one way of applying master loading to the air-flow controller. This pressure on diaphragm D is balanced on the controller's weigh beam against the differential pressure, across a section of the boiler or an orifice in an air duct, on diaphragm D_1. A change in master pressure on diaphragm D throws the beam out of balance and puts the regulator into operation to change the air flow in proportion to the change in master pressure. When this has been accomplished the change in differential pressure on diaphragm D_1 will have put the weigh beam in balance again to stop the regulator.

Master pressure is applied to the fuel-feed regulator, Fig. 6, in the same way as to the air-flow regulator. The differential pressure, Fig. 5, acting on diaphragm D_1 to put the air-flow regulator in balance, varies as the square of the change in air volume. To maintain the correct relation between air flow and fuel feed it is necessary that the fuel-feed regulator be balanced by a force that varies as the square of the change in fuel feed. This can be accomplished in several ways, such as a small fan, oil governor or electric generator driven by the fuel feeder, or in the case of pulverized coal, the differential pressure across the pulverizer may be used as the balancing force. For gas or oil firing, the differential across an orifice in the fuel line may be used.

In Fig. 6, the weigh beam is balanced by a diaphragm that may be connected to a small fan driven by the fuel-feed system. A change in steam pressure produces a change in master loading on diaphragm D which unbalances the weigh beam and puts the regulator in operation to correct fuel feed to the new steam demand. When this has been done, the regulator will again be put in balance by pressure from the tachometer fan on the fuel feeder.

Furnace pressure, for all systems, is usually controlled independently of the master system by a separate regulator. If the air-flow regulator adjusts the induced draft then the furnace-draft regulator controls the forced draft to maintain constant furnace pressure.

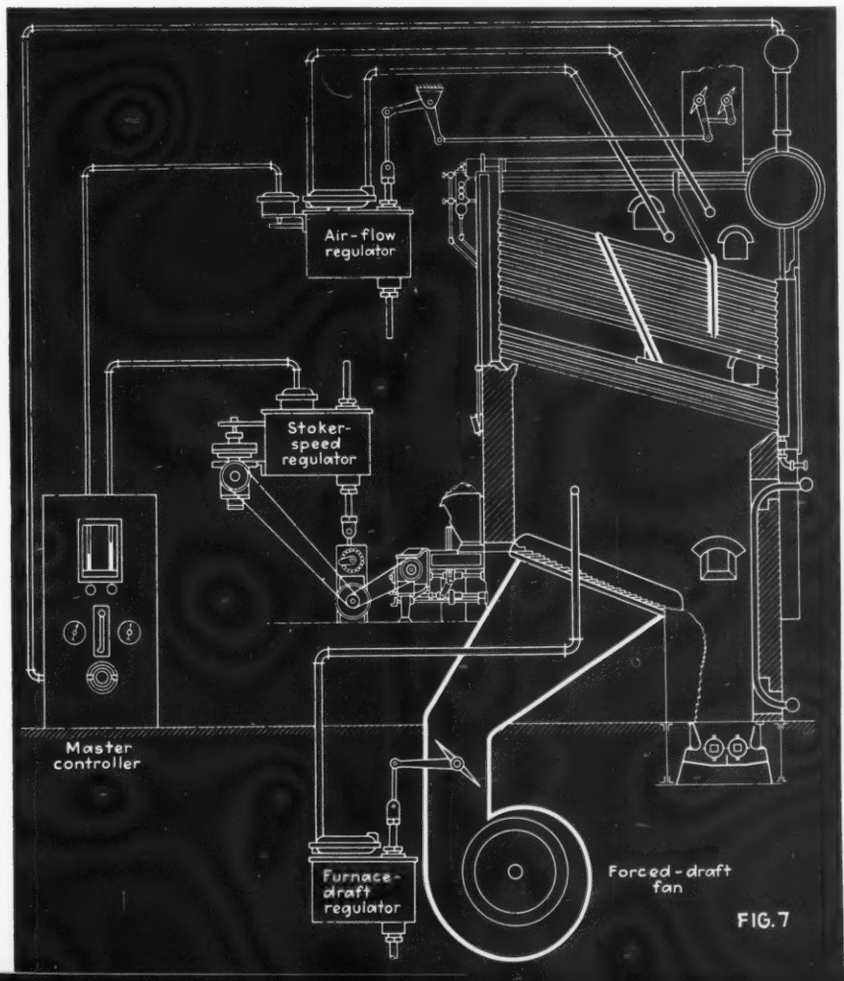
Fig. 7 shows one arrangement of master controller, air-flow, fuel-feed and draft regulators applied to control a stoker-fired boiler. An independent master loading pressure is sent to the air-flow and fuel-feed regulators. In this case, air flow is controlled by stack damper adjustment, and master loading pressure is balanced by the differential across a baffle in a boiler pass. Master pressure applied to the stoker-speed regulator is balanced by an oil governor that applies a force to the weigh beam which varies as the square of stoker speed. As the air-flow regulator adjusts the stack damper, the furnace-draft regulator adjusts the forced-draft damper to maintain constant furnace pressure.

In the system of Fig. 7, each regulator is independent to act until it has satisfied the demands made upon it by the master regulator. Fuel and air are metered, the former by stoker speed as determined by the oil governor and the latter by the differential across the boiler baffle. For this reason, combustion-control systems in which the air flow and fuel feed are adjusted according to master impulses are frequently referred to as metered control, as distinguished from systems having the fuel and the air regulators rigidly tied together and positioned by steam pressure.

Metered automatic systems of combustion control include many refinements not mentioned in the foregoing. They all have means for readily adjusting fuel-air ratio from the master panel. All systems incorporate means for readily changing from automatic to manual control.

Some systems include means of compensating either the fuel-feed or air-flow controllers to maintain constant CO_2 in flue gas. In other systems the initial adjustment of fuel and air is made from steam pressure by the master impulse, then air flow is adjusted if necessary for air-flow steam-flow relation by a connection to the air-flow element of a boiler meter. Many of these refinements will be brought out in following articles.

Fig. 7—Diagram of stoker-fired boiler operated from master controller panel, air-flow, stoker-speed and furnace-draft regulators



Automatic Combustion-Control Systems

• Automatic regulators for adjusting air flow or fuel feed date way back in boiler-plant operating history, but systems of automatic combustion control whereby a group of boilers can be operated as a unit are a product of the last 15 yr. In this period tremendous advances have been made in their development, and combustion-control systems are now available to operate boiler plants at maximum efficiency under almost any condition. All systems are centered in a master control which, in response to steam-pressure changes, sends either air pressure, a hydraulic, or an electrical impulse to individual fuel-feed and air-flow regulators.

Descriptions of the systems include only one application, but these equipments are adapted to stoker- pulverized-coal, oil- and gas-fired boilers requiring either a simple or an extensive system of combustion control.

Republic

• Low-pressure air supplies master impulses for the Republic Flow Meters Co., Smoot system of combustion control. Air-flow and fuel-feed regulators may be either compressed-air or pressure-oil operated.

In the master regulator, Fig. 1, steam pressure is applied under spring-loaded diaphragm D, connected to bleed valve B by lever L. Air is admitted to the bleed chamber through throttle valve T, adjusted to limit loading pressure to about 10 in. of mercury at minimum load. Loading pressure connected into compensating chamber C acts on diaphragm D_1 connected to lever L. Loading pressure is also connected to the fuel and air-regulator loading elements.

Assume a drop in steam pressure, indicating a demand for increased combustion. Diaphragm D will then move down and bleed valve B will rise slightly to raise the loading pressure to the air and fuel regulators to increase combustion rate. An increase in steam pressure will produce an opposite effect. The master is so designed that a given change in steam pressure produces a definite change in air flow and fuel feed to the boiler. This function of the steam-pressure element provides a stabilizing characteristic to the control system, which prevents hunting and is adjustable over a wide range.

The increase in loading pressure on diaphragm D_1 of the compensator is applied downward on the right end of lever L and tends to push it to a lower level than allowed by decreased steam pressure under diaphragm D. This effect is used to cancel out the stabilizing characteristic of the master regulator by slowly returning steam pressure to its original value after an increase in demand. Each regulator-loading element has a ratio needle valve V for adjusting the ratio of regulator loading pressure to master loading pressure, thus adjusting the fuel-air ratio.

A 90-deg. turn of transfer valve V_1 counter-clockwise changes the unit from automatic to manual control. Then by turning handwheel H to adjust bleed valve B_1, the operator can adjust boiler load at will.

With this system of combustion control, either hydraulic-type or air-operated regulators may be used. As operation of these regulators is similar in principle and application, only the hydraulic type, Fig. 2, will be described. This regulator comprises a measuring element, an amplifier, a stabilizer and a power element. Pressure oil is admitted to the middle chamber of a pilot valve P, then to above differential piston C of the amplifier and through a needle valve N to the under side of C. Oil from below piston C flow continuously to the drain through multiplying valve M, the stem of which connects to weigh beam W, fulcrumed at F, and connected to diaphragm D.

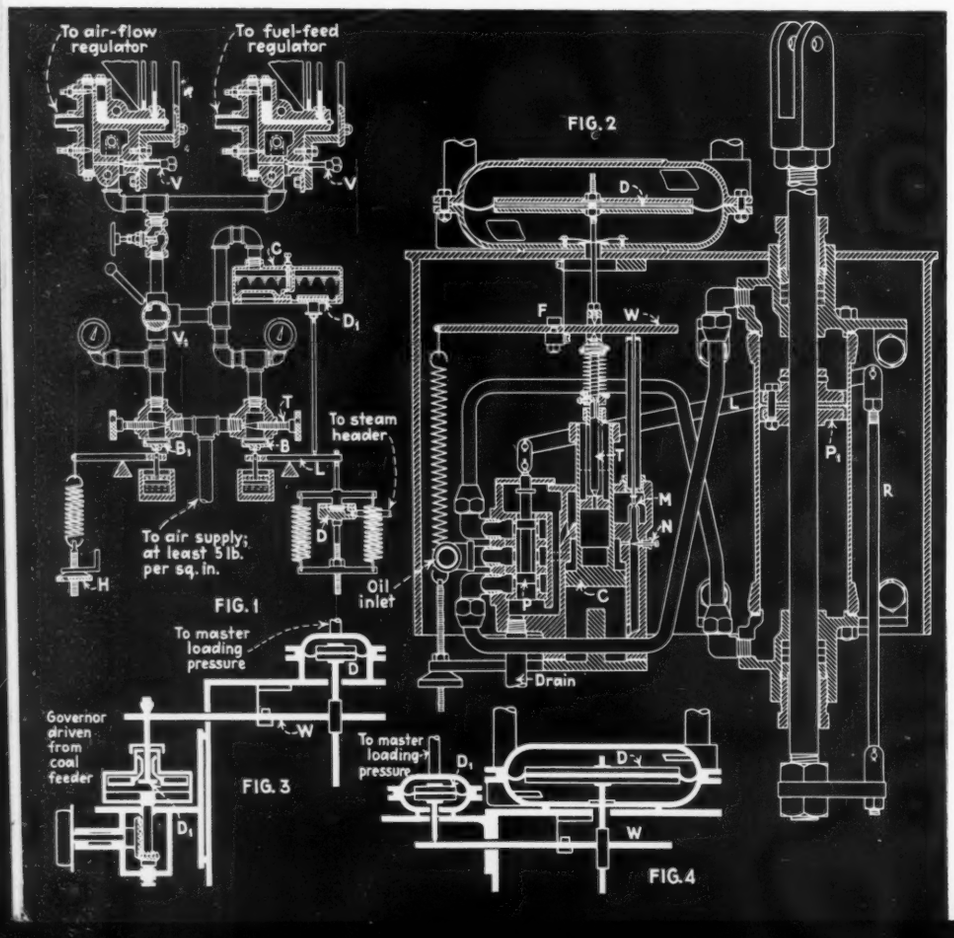


Fig. 1—Master controller for Smoot system of automatic combustion control. Fig. 2—Hydraulic-type regulator combines control element and power cylinder. Fig. 3—Speed governor and master loading element applied to regulator, Fig. 2, for controlling coal feed. Fig. 4—Differential-pressure and master loading element applied to regulator, Fig. 2, when controlling air flow

Movement up or down of the right-hand end of beam W increases or decreases the opening of valve M and in this way reduces or multiplies the pressure under piston C. The area above piston C is half that below, therefore when pressure in the bottom chamber is half that in the top one, piston C will be in equilibrium. Pilot valve P connects to one end of return-motion lever L, fulcrumed on the top of piston C.

Assume that the regulator is used for controlling furnace pressure, applied under diaphragm D. A decrease in this pressure causes weigh beam W to close slightly multiplying valve M, thus increasing the restriction to oil flow from the valve and causing an increase in pressure under piston C. The piston then moves upward and opens pilot valve P, as shown, to admit pressure oil under power-element piston P_1, and releases oil from above the piston to the drain. Piston P_1 starts moving upward to adjust air flow to correct furnace draft. Return-motion lever L connects to the power-cylinder piston rod by rod R, so that as piston P moves up it moves pilot valve P down to close both ports from the power cylinder and stops its piston.

A stabilizing oil dashpot in amplifier piston C connects to weigh-beam W. The lower end of stem T acts as a needle valve in the port in the dashpot bottom. This part of the regulator acts as the stabilizer to prevent over-travel or hunting by dampening the movement of weigh beam W. Movement of amplifying piston C tends to return the weigh beam to neutral, thus anticipating the return of the controlled pressure to normal. Returning the weigh beam to normal positions the multiplying valve to equalize the forces on the amplifying piston, and it comes to rest. As oil pressure under the dashpot plunger is gradually relieved by oil passing through its orifice, upward force on the weigh beam is gradually decreased. The stabilizer enables the regulator to make its correction of the disturbed quantity, then by prematurely balancing the weigh beam prevents the regulator from over-travel or hunting.

Regulators for controlling furnace draft, air flow or fuel feed are identical except in manner of application. For control of air flow by measuring the differential pressure

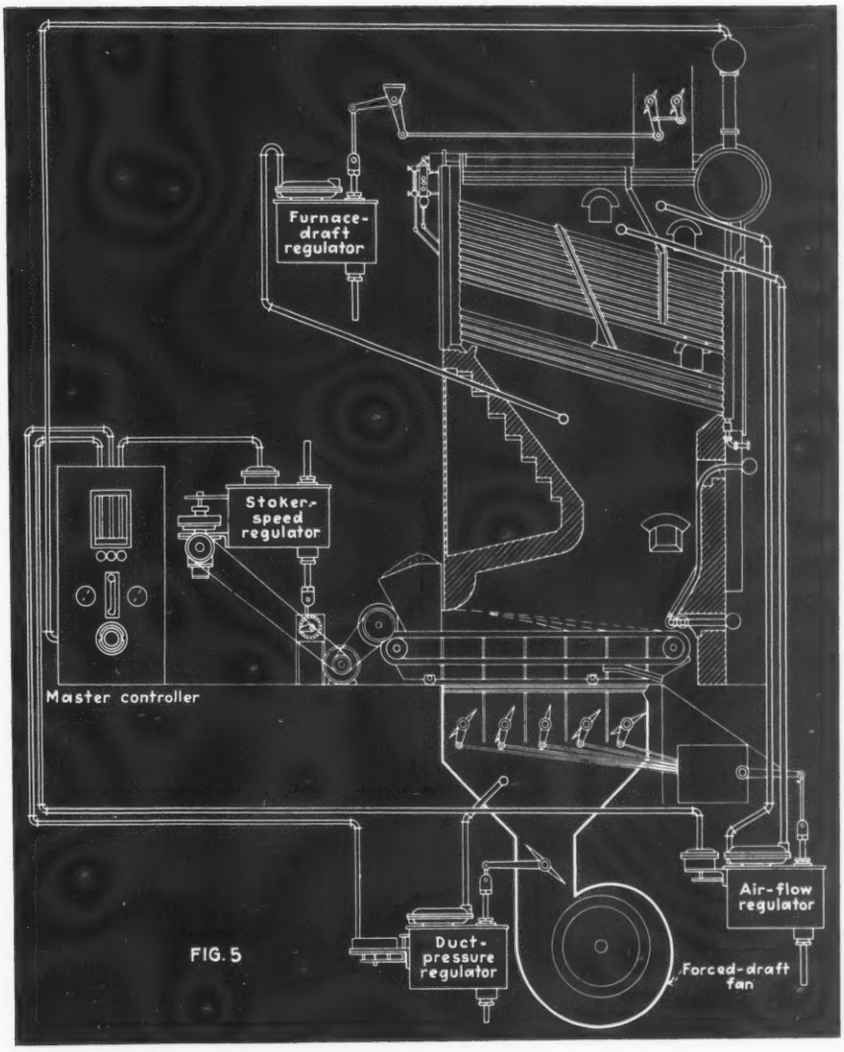


Fig. 5—Combustion-control equipment, Figs. 1 to 4, applied to chain-grate stoker-fired boiler. Each stoker zone is provided with a damper for controlling the air to that particular section of the grate

across a boiler, master- and differential-pressure elements are connected to the regulator, as in Fig. 4. Master-loading pressure above diaphragm D_1 is balanced against differential pressure across the boiler on diaphragm D. A drop in steam pressure will cause an increase in master-loading pressure on diaphragm D_1, unbalancing weigh beam W to cause the regulator to increase the air flow. The resultant increased differential pressure across the boiler acting on diaphragm D balances weigh beam W to put the regulator in equilibrium.

Fig. 3 shows how the regulator is applied for fuel-feed control. Weigh beam W is balanced by master loading pressure or diaphragm D on one end and the force of an oil governor, driven from the coal feeder at the other. The speed-governor control element consists essentially of an oil chamber with a stationary metallic disk D_1 suspended horizontally in the center by a rod connected to weigh beam W. As the chamber rotates, centrifugal force causes the oil to produce a difference of pressure across the disk that varies as the square of oil-chamber speed, to balance weigh beam W against master loading pressure on diaphragm D. An increase in loading pressure, corresponding to a demand for more steam from the boiler, will depress the right-hand end of beam W, causing the regulator to speed up fuel feed. As the oil governor speeds up, downward force on its disk increases to again balance the weigh beam and stop the regulator.

Fig. 5 is an application of the equipment just described to a forced-draft, chain-grate fired boiler. The steam header is connected to the master controller, which connects to stoker-speed, air-flow and duct-pressure regulators, the forced-draft fan

being driven at constant speed. Impulses are sent out by the master to each of these regulators in response to changes in steam pressure, to supply the correct amount of fuel and air in the ratio that will give maximum combustion efficiency at all ratings. Stoker-speed regulator operates a rheostat controlling stoker speed to regulate fuel input as measured by the speed-governor element on the regulator. The air-flow regulator operates dampers in each stoker air zone by adjustable cams and suitable linkages to control air flow through the boiler.

The air-flow controller not only measures the correct total quantity of air, but distributes it to the proper zones, lengthening and shortening the fire in proportion to steam demand. Constant air pressure is maintained in the air duct by the duct-pressure regulator, except for sudden load changes when temporary increase or decrease of pressure is necessary. A stack damper is operated by the furnace-draft regulator to maintain the desired combustion-chamber pressure.

Bailey

• The primary function of any combustion-control system is to supply fuel and air, in correct ratio, to boilers in proportion to steam demand. The air-operated system of Bailey Meter Co. does this by adjusting fuel and air proportions simultaneously, then readjusts air supply in accordance with steam flow until best combustion efficiency is obtained.

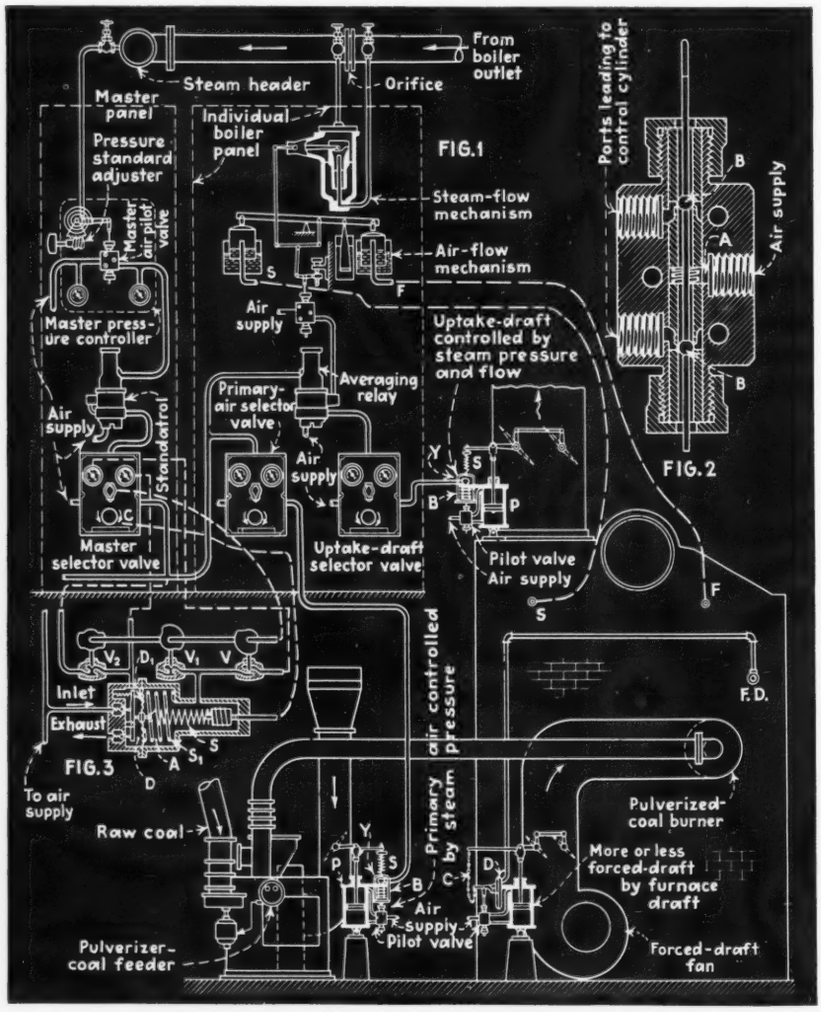
Fig. 1 shows an application to a pulverized-coal fired installation. A master-pressure controller sensitive to steam-pressure variations is connected to the main steam header. It consists of an adjustable-pressure helix or Bourdon tube linked to an air pilot valve, Fig. 2. These balanced, free-floating pilot valves are used throughout the system. Air is admitted at A to the space between the two balls B on the valve stem. As the balls are of equal size, the valve is balanced. The balls, however, are slightly smaller in diameter than the valve sleeve, to allow a small quantity of air to escape, which acts as a lubricant. Ports in the valve sleeve connect with control lines. The valve in Fig. 2 is the double-acting type used as a relay with piston-operated control drives. When used with master and steam-flow, air flow controllers, one of the control-line openings is plugged and the valve becomes single-acting.

When the valve is supplied with filtered air at a constant pressure of 35 lb., each position of the pilot-valve stem causes a definite pressure in the outlet port and control line varying between 5 and 25 lb. for full-range movement of the pilot. This line is connected to the Standatrol, Fig. 4, which stabilizes the control system. It is particularly useful with control applied where an appreciable time lag interval occurs between a change in fuel and air supply and the resulting change in the rate of steam generation.

The Standatrol consists of chambers A and B separated by diaphragm D, and chambers C and F separated by diaphragm D_1. A metal bellows isolates B from C. Spring S and diaphragms D and D_1 are attached to the center post E. When it moves downward, E acts on pivoted beam P to open air-admission valve V and closes atmospheric valve V_1. For an upward movement of post E, valve V_1 opens and V closes. Tension in S is adjusted to balance force exerted on D by 15-lb. pressure in A when pressures in F and C are equal.

If master loading pressure in A is increased, the united action will tend to increase control pressure in F an equal amount. This pressure, however, immediately starts to bleed through throttling valve T into C. Increasing pressure in C forces the center post downward and increases the pressure in F still more. The action is regenerative and the pressures will continue to increase to a maximum unless loading pressure in

Fig. 1—Pulverized-coal fired boiler, which has primary air controlled by steam pressure, and the stack draft by combination of steam-pressure and steam flow. Fig. 2—Cross-section of Bailey air pilot valve. Fig. 3—Cross-section of selector valve, which permits changing from automatic to manual control



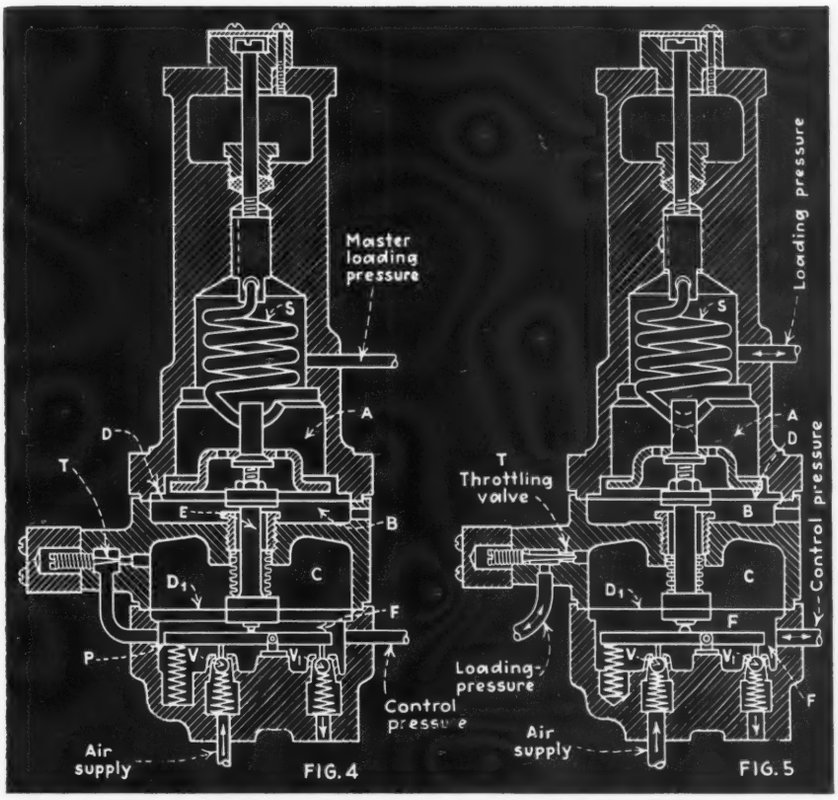


Fig. 4—Cross-section of Standatrol that stabilizes operations and prevents tendency to hunt under unfavorable operating conditions. Fig. 5—Cross-section of averaging relay used to connect two or more controlling sources to one control drive

A returns to normal. Action is reversed with a decreased loading pressure.

The control system is only in equilibrium when the loading pressure is 15 lb. with steam pressure at the setting of the master pressure controller. When a change in steam pressure occurs, a continuous change is made in the control pressure to the various regulators until the Standatrol is restored to balance by return of steam pressure to normal and loading pressure to neutral. As loading pressure approaches neutral, its effect on the diaphragm assembly retards the regenerated action of the bleed to chamber C so that the control pressure gradually comes to rest without over-shooting or hunting.

The standardized loading pressure set up by the Standatrol goes to the master selector valve, Fig. 3. This device gives flexibility to the system by providing a means of changing from manual to automatic control of boiler output. The selector valve has two chambers A and D separated by diaphragm D_1 loaded by tension spring S and compression spring S_1. When pressures in A and D are equal and springs S and S_1 are balanced to oppose each other, the unit is in equilibrium. A change in loading pressure applied to chamber A will operate the inlet and exhaust valves to set up a corresponding pressure in D. This is normally the operating condition with the transfer valves V and V_1 open and V_2 closed. When on manual control, transfer valves V_1 and V_2 are open and V closed. Turning knob C, Fig. 1, varies the spring load on diaphragm D_1 and enables any desired control pressure to be set up in D. This master loading pressure is then carried to the individual boiler panels. Selector valves are also used on individual control drives to adjust them in relation to the balance of the system.

At the individual boiler panel, Fig. 1, the loading pressure takes two different paths. One path is through the primary-air selector valve to the primary-air control drive. At this control, loading pressure acts on a small metal bellows B which in turn moves a double-acting relay pilot valve (cross-section, Fig. 2) to admit air to one side of a power cylinder P to open or close the damper. Movement of the damper readjusts the pilot valve by means of yoke Y and spring S. Rate of raw-coal feed is varied independently by a pulverizer-feeder controller which maintains the correct coal level for output.

The other path for master control pressure is through an averaging relay, the uptake-draft selector valve, to the uptake-damper control drive Movement of the uptake damper changes pressure in the furnace and the furnace-draft regulator adjusts forced draft to the burners to restore the furnace pressure to normal.

After these changes have been made it may be necessary to readjust the air-flow slightly to secure the most efficient combustion. This is done by the boiler meter, Fig. 1, which is a combination of two flowmeters one measuring and recording steam flow from the boiler and the other air flow. This meter is arranged so that when combustion is at its most efficient point the positions of the air-flow and steam-flow pens coincide. A single-acting pilot valve is connected by linkage to the pen mechanisms so that it is actuated when the pen positions are not the same. Should the air-flow pen rise above the steam-flow pen, indicating too much excess air, the pilot valve would be moved slightly to change the loading pressure sent to the averaging relay.

The averaging relay, Fig. 5, is similar to the Standatrol, Fig. 4, except that the pipe connecting chamber F to chamber C is removed and C connects to the loading pressure from the air-flow, steam-flow pilot valve. When so connected, control pressure to the uptake-draft control drive is the algebraic sum of the loading pressures received from the master pilot valve and the steam-flow air-flow pilot valve. Therefore, any change in loading pressure from the air-flow steam-flow pilot valve will readjust the position of the damper and bring the steam-flow and air-flow pens back together for best combustion results. The loading pressure entering the averaging relay from the boiler meter pilot valve is throttled at T so that its effect is slower than that of the master loading pressure. This gives the master regulator precedence over the steam-flow air-flow adjustment.

Furnace-draft regulator Fig. 1 comprises a large diaphragm D, sensitive to changes in furnace pressure and a double-acting air pilot which regulates the pressure on the control-

drive operating piston. Movement of the piston repositions the pilot valve by a chain compensating device C. As the piston moves up and down the chain adds or diminishes the counterbalance weight until the pilot valve is again in its neutral position and stops regulator movement.

Hagan

• Air at about 75 lb. per sq.in. pressure is the common operating medium used for the automatic combustion-control system of the Hagan Corp. The system is so designed that the operating pressure varies from about 10 lb. at maximum boiler rating to 50 lb. at the lowest rating.

The master sender, Fig. 1, as in other systems, operates in response to changes in steam-header pressure to supply varying control impulses. Header pressure applied outside a metal bellows B acts upward on a balanced lever L and is opposed by a spring S. The control valve V has two seats, C and C_1, between which it operates, and is connected flexibly to lever L. Air at constant pressure is supplied to the bottom of the control valve, and an impulse-pressure connection to the compensating relay and manual control is made at the side.

Port C of valve V connects to atmosphere. If the valve moves downward and closes port C_1, impulse pressure will drop to zero. Raising the valve to close port C allows impulse pressure to build up to air-supply value. Then, any pressure between these may be had in the impulse system by positioning valve V to throttle supply air through port C_1 and bleed through C. In this way, impulse pressure is decreased and increased as station load increases and decreases respectively.

The combination compensating relay and manual control has two diaphragms D and D_1 with a spacer block between them. Impulses from the master sender come through the automatic- to manual-control transfer valve into the spring housing and acts on diaphragm D, forcing it to the right for an increase in impulse pressure. This moves pilot valve P to admit air from the supply to the sender line and to diaphragm D_1. When the pressure on D_1 is slightly greater than on D pilot valve P closes. If pressure on D is decreased, pilot P moves to the left and exhausts from the sender line until pressure on D_1 equals D when the pilot closes. In this way, impulses sent out by the master are reproduced by the compensating relay.

For manual operation of a bank of boilers, the transfer valve is turned to manual and knob H is used to increase or decrease the tension of spring S_1, which has the same effect as increasing or decreasing master sending impulses.

All the parts for regulating stack draft are shown in Fig. 2. These include a fractionating valve, a leak-off valve, a diaphragm regulator and a power-regulating unit to operate the uptake-draft equipment. The diaphragm regulator comprises a sensitive diaphragm D freely suspended on a pivoted balance beam B. Pressure to be regulated, if positive, is applied above this diaphragm and below if negative, so that it is subjected to a downward force that is

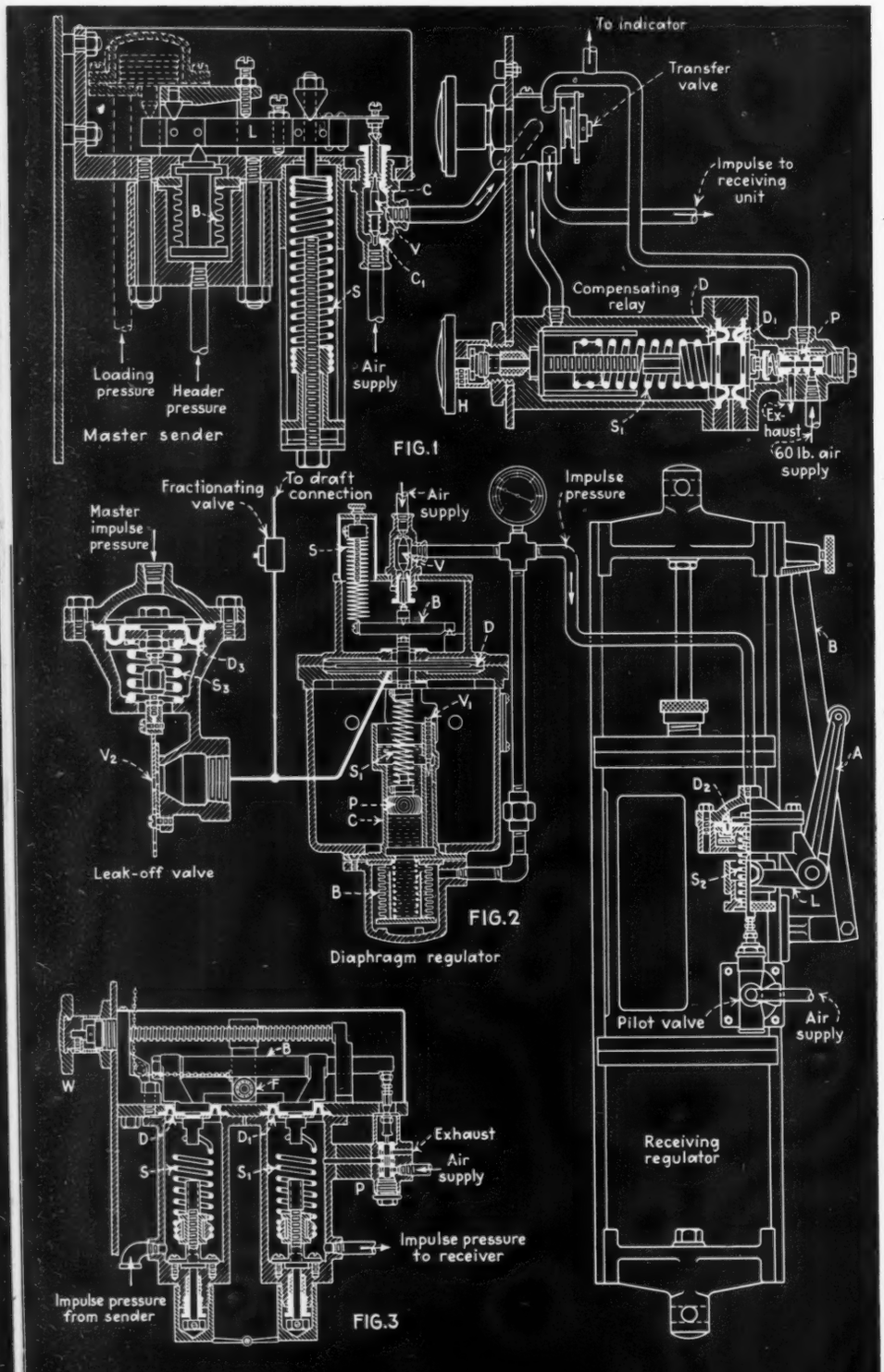


Fig. 1—Hagan master sender, compensating and manual to automatic-control and transfer valve. Fig. 2—Equipment for controlling air flow, using leak-off valve, diaphragm regulator and receiving power regulator. Fig. 3—Ratio relay permits adjusting fuel-air ratio and maintains that ratio

opposed by spring S. Adjustment of spring S determines the regulated pressure. Movement of diaphragm D determines the position of escape valve V, which has two small ports. Air at constant pressure is admitted through the top port and exhausted to atmosphere through the bottom one and therefore controls the impulse pressure as does the master regulator. A helical spring attaches below diaphragm D and to piston P, which moves freely in cylinder C filled with oil. An increase in impulse-air pressure, caused by a downward movement of diaphragm D, compresses bellows B and lifts the oil, raising piston P to compress spring S_1, which reacts on the diaphragm to oppose its downward movement. An adjustable port allows oil to gradually flow around piston P so that it gradually returns to normal position and releases the tension in spring S_1 created by a change in impulse pressure. The time for the oil release can be adjusted by valve V_1 to suit the lag of the system being regulated. The gradient of spring S_1 and of valve V_1 provides wide compensation adjustment to suit requirements of the system being controlled.

Diaphragm-regulator impulses are transmitted to the top of diaphragm D_2 of the draft-regulator, and is opposed by spring S_2. The lower end of spring S_2 is carried in an adjustable socket supported by forked lever L to which compensating arm A is rigidly attached. At its upper end, arm A is carried on the compensating bar B by a ball bearing-roller. An increase in the sending impulse from the diaphragm regulator will force diaphragm D_2 downward to open the pilot valve, admitting air under the power piston and causing crosshead C to move upward. Compensating bar B is also moved upward, and in so doing forces compensating arm A outward to increase tension in spring S, forcing diaphragm D back to neutral position and closing the pilot valve to stop the regulator.

The uptake-draft connection to the control system, Fig. 2, is made to the leak-off valve and to the underside of diaphragm D_1, through a fractionating valve. The latter is a throttling orifice for adjusting the suction pressure to be maintained on diaphragm D of the diaphragm regulator. Master-sender impulse pressure is applied above diaphragm D_3 of the leak-off valve. At minimum load, master-impulse pressure will be at a maximum and will close shutter valve V_2, giving a suction pressure on diaphragm D equal to that at the draft connection. By the action of the leak-off and fractionating valve this pressure is held practically constant on diaphragm D up to maximum draft.

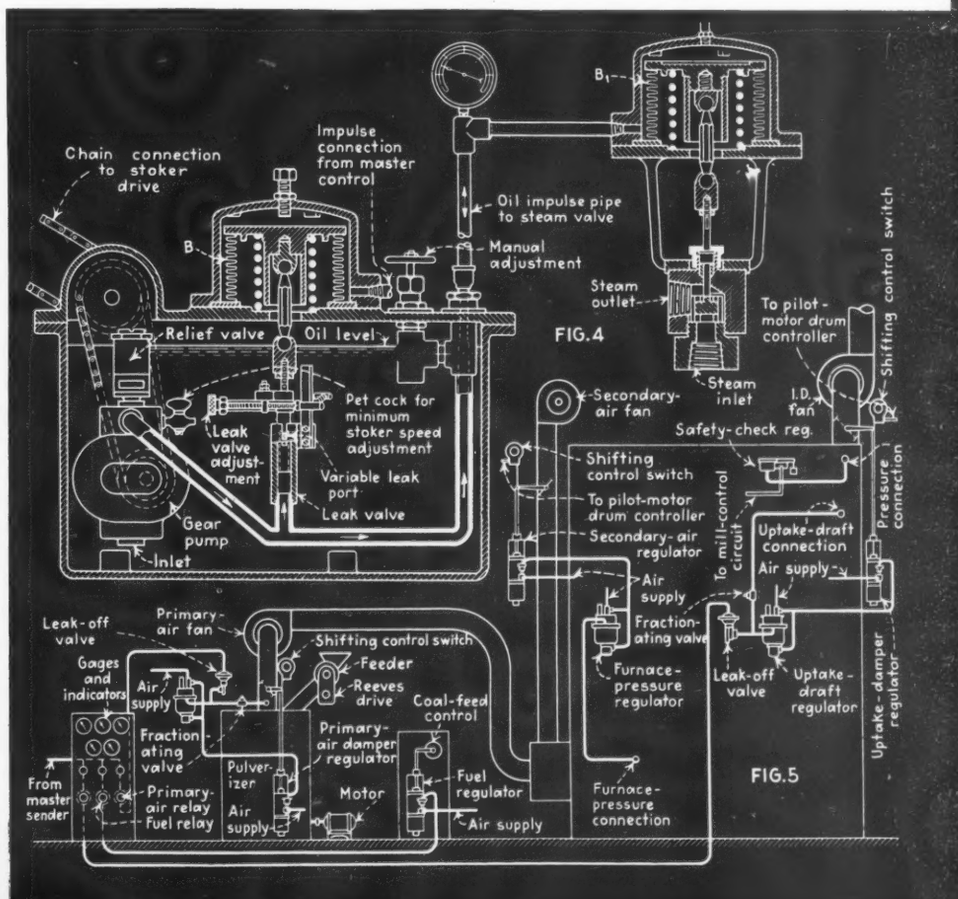
As master-impulse pressure decreases on diaphragm D_3, with increasing loads, shutter valve V_2 is opened by spring S_3, to allow an air leak into the draft connection, sufficient to balance the increase in draft outside the fractionating valve. Assume a decrease in master impulse pressure. Spring S_3 will open valve V_2 in proportion to master-pressure decrease. Momentarily this causes a decrease in suction on diaphragm D and it moves valve V upward slightly, which movement reduces the impulse pressure. A reduction in impulse pressure on diaphragm D_2 allows spring S_2 to raise the pilot valve to admit air pressure above the regulator piston to open the damper. The damper opens until the uptake draft reestablishes normal suction on diaphragm D and it returns valve V to its original position. As the regulator piston moves downward, the compensation functions to reduce the tension in spring S_2 to return the pilot valve to neutral and stops the regulator.

Fuel-air ratio may be adjusted by the adjustable-ratio relay, Fig. 3. Pilot valve P is actuated by the freely balanced beam B supported on a ball-bearing fulcrum F. This beam is subjected to opposing forces of springs S and S_1 and pressure on diaphragms D and D_1. Master-pressure impulses are applied under diaphragm D and impulse pressure under diaphragm D_1 actuate the fuel-regulator. On a decrease in master pressure spring S raises pilot valve P and reduces the impulse pressure under diaphragm D_1. This reduction in pressure transmitted to the fuel regulator causes a speeding up in fuel-feed rate as previously explained.

With fulcrum F midway on beam B, as in the figure, equal pressure on the diaphragms puts the beam in balance when pilot valve P is closed. A shift of fulcrum F to the right, by turning handwheel W, requires a higher pressure under D_1 than under D to balance the beam. Moving fulcrum F to the left requires a higher pressure under D than D_1 to balance beam B. In this way impulses to the coal feeder can be made higher or lower than the master, simply by turning wheel W.

A variable-speed governor for the coal-feed drive is shown in Fig. 4. It comprises a small rotary, positive-

Fig. 4—Variable-speed governor for engine or turbine stoker drives. Fig. 5—Automatic combustion-control system, Figs. 1 to 3, applied to control of pulverized-coal-fired boiler



displacement oil pump, driven from the coal feeder. When the governor regulates speed of an engine or a turbine, oil pressure from the pump is applied to a bellows-operated steam valve. Master impulse pressure is applied outside bellows B connected to a variable leak-off valve that regulates pressure on bellows B_1 of the steam valve. On a decrease in master pressure, denoting an increase in load, bellows B expands, which enlarges the leak-off valve port to reduce the oil pressure on bellows B_1. This increases the steam valve opening to speed up the fuel-feed drive.

Fig. 5 shows the combustion-control equipment connected to handle a pulverized-coal-fired job on which the draft fans are motor driven. Operation of the system can be readily followed from the previous explanations.

General Regulator

• A feature of the General Regulator Corp. system of automatic combustion control is a compact regulator so designed that it may be used for air-volume, fuel-feed or furnace-draft control or as a master regulator. The only change in the regulator for the different services is in the method of loading the weigh beam, O, Fig. 3, which may be a diaphragm, Bourdon tube, solenoid or other suitable means. Its stabilizing force is obtained from the pressure-operating fluid (oil at 100 lb. per sq. in.) discharged through a jet onto an arm to which the amplifying valve is responsive.

Cross-sections of the regulator are shown in Figs. 1 to 4. The power cylinder, stabilizing valve and relay valve are clearly indicated. Rod R passes through the double-area balanced regulating piston, is pinned to it at A, passes down through a clearance hole in the stabilizing and relay valves and is connected to the return-motion mechanism at M. This rod connects to the relay and stabilizing valves through links B, C and D, link D being fulcrumed at F.

Restoring cam E is mounted on a shaft, Fig. 2. One end of restoring arm G rests on cam E, is fulcrumed at H, and connects to bar B by link J. A roller chain connects pulley L on the restoring camshaft to the top of the piston rod of the power cylinder. Tension is maintained in this chain by a heavy spiral spring M so that the restoring cam follows power-piston movement.

Pressure to be regulated is applied to the top side of the diaphragm N, the bottom side of which is in contact with weigh beam O by a pivot rod, Fig. 3. This beam is supported between knife edges and is weighted on the end opposite to the diaphragm. It is connected near its center, Figs. 2 and 3, by a pivot rod to a lever on the shaft S, (Figs. 1 to 3) that carries the regulating arm Q. In this arm is the amplifying valve that regulates the flow of oil from the regulating cylinder, and it is also acted upon by two stabilizing oil jets.

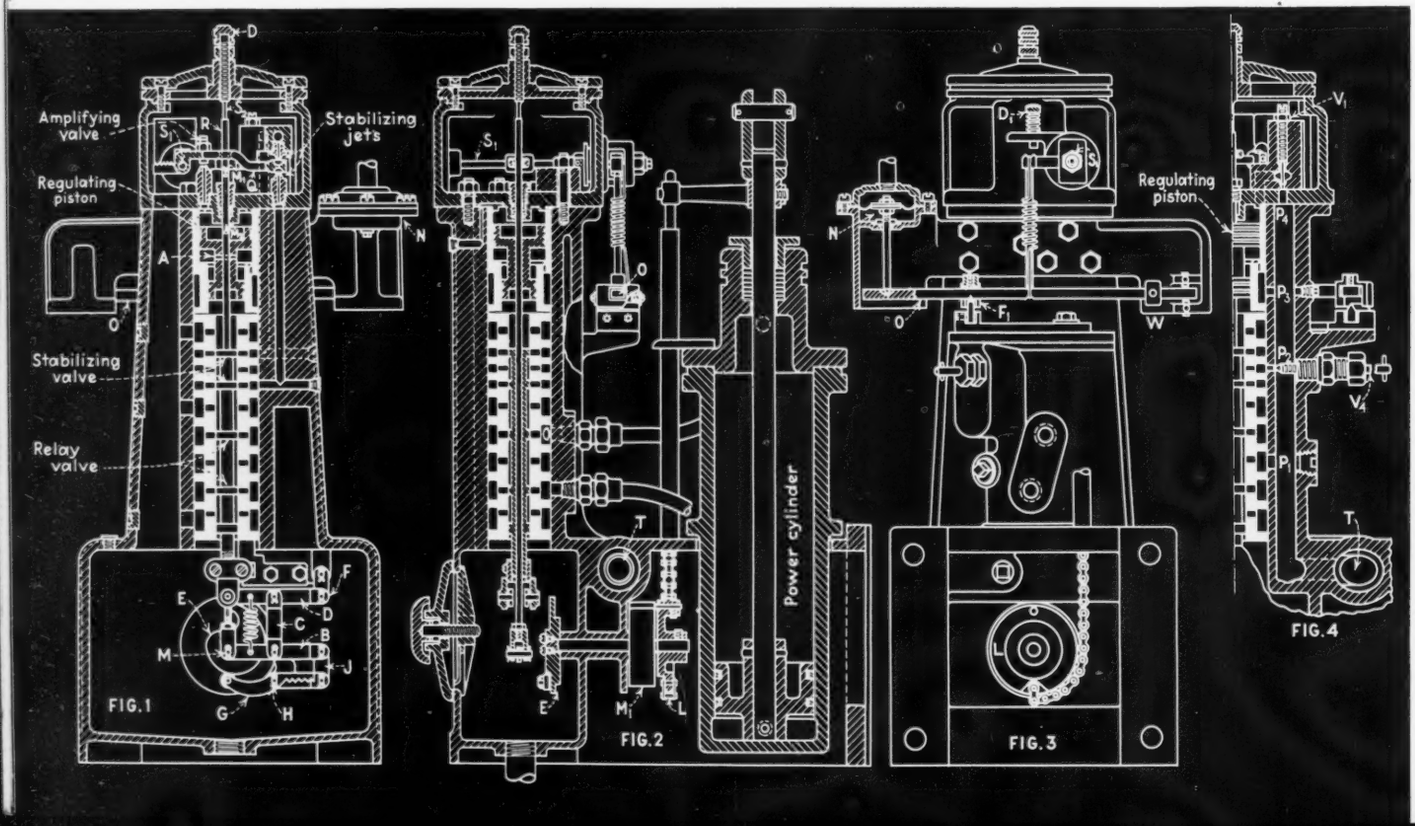
In Fig. 4, pressure oil enters the regulator at T and goes to the relay-valve through port P_1 to the stabilizing valve through port P_2 and to the regulating piston through ports P_3 and P_4. Oil flowed through P_4 is restricted by needle valve V_1 so that the pressure on top of the regulating piston may be readily controlled by the amplifying valve, Fig. 1.

Assume the regulator to be balanced and controlling pressure and that load changes cause diaphragm N to rise. This will turn shaft S_1 to restrict oil flow through the amplifying valve, Fig. 1, and increase pressure above the regulating piston, causing it and the stabilizing and relay valves to start moving downward.

Downward movement of the stabilizing valve opens its bottom port to the pressure oil, which flows up through the outside passageway to a nozzle under regulating arm Q. The oil jet from the nozzle is applied upward against arm Q and tends to restore it to its original position to prevent over-travel. Opening the bottom port of the relay valve admits pressure oil to the under side of the power piston. The top port of the relay valve is opened to discharge so that the power piston starts to move up.

Upward movement of the power piston turns the restoring cam in a clockwise direction, which pushes down the left-hand end of arm G and raises the right-hand end. This action moves the relay and stabilizing valves upward toward their neutral position

Figs. 1 to 4—Cross-sections through a General regulator. This type is used for master, air-flow, fuel-feed and furnace-draft regulation, the only changes made are in the method of loading the weigh beam, as shown in Fig. 5



and reduces the stabilizing force on the regulating arm Q. The operation just explained is repeated until the demand is supplied by a smooth process and not a step-by-step action. For a decrease in demand, action of the various parts is the reverse of that just explained. From the foregoing it will be seen that the stabilizing jets act only while the regulator is in operation. When the regulator moves, there is produced a proportional stabilizing force, and when movement ceases the stabilizing force decreases to zero.

To provide manual control, the upper end of rod R is hollow and has port M_1 at all times and thus closes the passage in rod R form a bypass around the amplifying valve. During automatic operation, stem S_2 extends down into rod R sufficiently to cover port M_1 at all times and thus closes the bypass around the amplifying valve. For manual control, thumbscrew D_1, Fig. 3, is turned down to hold the amplifying valve closed, then as manual-control valve S_2 is screwed up, opening port M_1, the regulator piston will rise so port M_1 will always be partly closed by the valve stem. Therefore, the position of stem S_2 will determine the position of the regulator piston and consequently power-piston position.

Fig. 5 is a simplified diagram of an automatic system of combustion control using the regulator, Figs. 1 to 4. As previously explained, the only difference in the regulator for the various services is in the method of loading the weigh beam. Impulses from the master to the fuel-feed and the air-volume regulators, for more or less fuel and air, are transmitted electrically. When the regulator is used as a master, steam-header pressure acting on a Bourdon tube is balanced against a spring, and the power-cylinder piston connects to operate a potentiometer-type rheostat, as shown.

On the air-volume controller, the pull of a solenoid, energized from the master potentiometer, is balanced against the pressure differential across a section of the boiler or an orifice in the air duct. The weigh beam of the coal-feed regulator balances the pull of the master solenoid against the pull of another solenoid energized by a tachometer generator driven by the coal feeder. In some pulverized-coal installations, the master solenoid is balanced against a diaphragm to which the differential across the pulverizer is applied, as in Fig. 6. For furnace-pressure control, furnace suction acting on a diaphragm on one end of weigh beam O is balanced by tension of a spring on the other end.

In Fig. 5, a decrease in steam pressure causes the master regulator to adjust the potentiometer rheostat clockwise to increase the master impulse to the air-volume and fuel-feed regulators. This increases the pull on their master solenoids in a demand for more air and fuel. The air-volume regulator increases draft-fan speed or adjusts a damper to increase air-volume until differential pressure balances the pull of the master solenoid, to put the regulator in equilibrium. On the fuel-feed regulator, increased pull of the master solenoid acts to cause the regulator to increase the rate of fuel feed until the increased voltage of the tachometer generator produces a pull in its solenoid equal to that of the master, and puts the weigh beam in balance.

All solenoids are so designed that their pull increases as the square of the applied voltage. On the air regulator, master solenoid pull balances draft differential (which varies as the square of air volume), therefore correct relation between master loading and air volume is obtained. The tachometer generator is so designed that its speed-voltage curve is a straight line through a wide range. Consequently, on the fuel-feed regulator, the same relation exists between fuel-feed and master loading as prevails between master loading and air volume on the air-flow regulator. Fuel-feed and air volume then varies in a fixed ratio, in response to changes in steam pressure or other boiler conditions.

Fuel-air ratio may be adjusted by a rheostat, Fig. 5, in series with the solenoid coil on the air-volume regulator. A change is made to manual control by throwing the 2-pole, double-throw switch to the right. This connects in a manual-control potentiometer. Then by adjusting this potentiometer by hand, combustion rate can be changed at will.

Fig. 6 shows this system of control connected to regulate a pulverized-coal-fired boiler. The master connects to the steam header and sends through the master-control panel electrical-loading impulses to the air-volume and fuel-feed regulators. The air-volume regulator adjusts induced-

Fig. 5—Simplified diagram showing the regulator, Figs. 1 to 4, applied to controlling a single boiler or a group

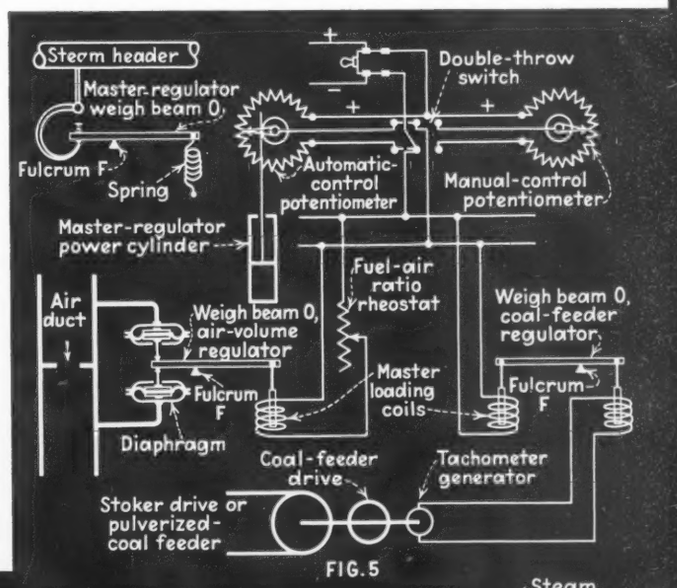


FIG. 5

Fig. 6—Regulator, Figs. 1 to 4, applied to controlling air flow, fuel feed and furnace draft on a pulverized-coal-fired boiler

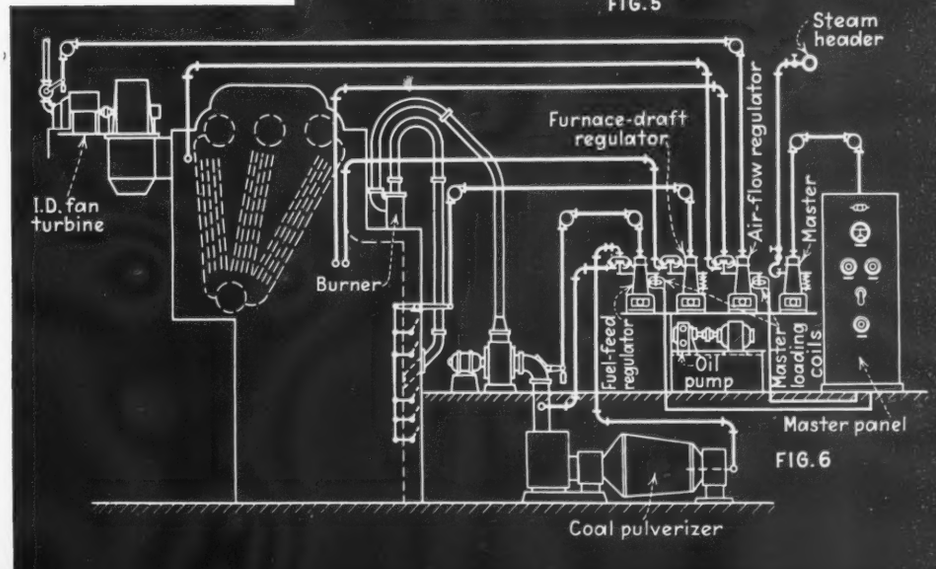


FIG. 6

draft-fan turbine speed and has its master-loading solenoid pull balanced by draft-differential across the boiler. The pull of the fuel-feed regulator master solenoid is balanced against differential air pressure across the pulverizer, which gives an accurate measurement of coal delivered. This regulator controls coal feed by adjusting a damper in the primary-air duct. The furnace-draft regulator has its diaphragm connected to the furnace, and regulates combustion-chamber pressure by adjusting secondary-air dampers at the front of the furnace. The master-pressure regulator has entire charge of steam generation by its connection to the master-control panel.

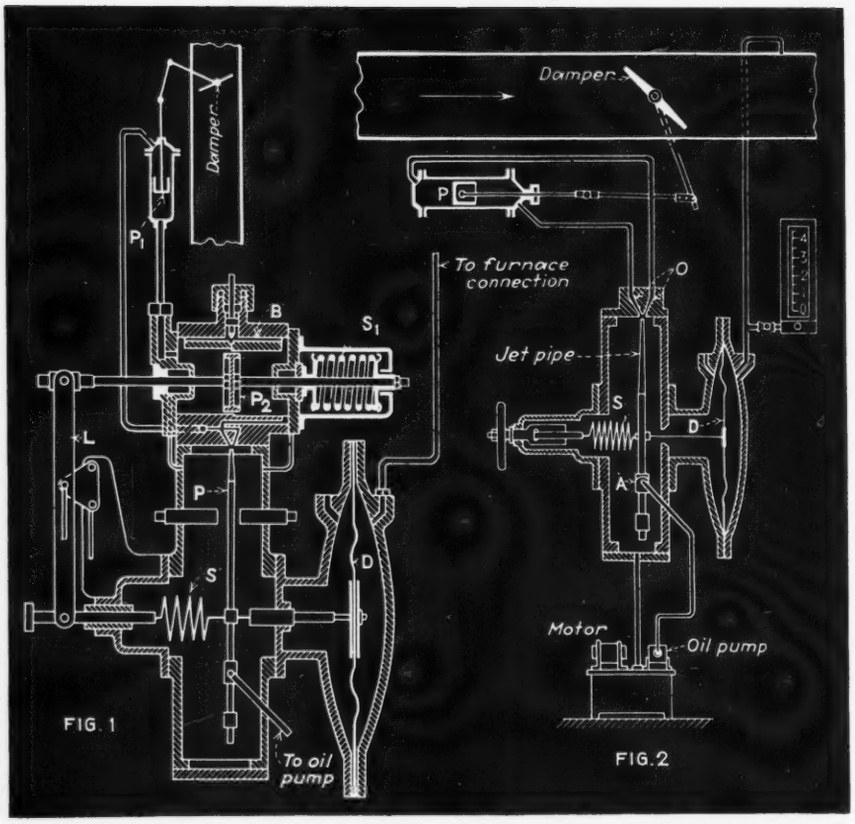


Fig. 1—Hydraulic stabilizer applied to regulator Fig. 2 for controlling furnace pressure. Fig. 2—Askania regulator applied to maintain constant pressure in gas main

Askania

• In the Askania system of automatic combustion control, the basis of each regulating unit is a jet pipe, Fig. 2. Oil at about 60-lb. pressure, supplied by a pump, enters the jet pipe at *A* and discharges toward two orifices *O*. The jet pipe is supported vertically on a pivot bearing and is free to swing horizontally. With the jet pipe in its central position the oil stream from the nozzle strikes with equal force against the two orifices and pressure acting on each side of the power piston *P* are balanced. Oil from the jet runs down to the bottom of the casing and returns to the intake of the pump.

Fig. 2 shows the regulator connected to maintain constant pressure in a gas main. The jet pipe is balanced between a spring *S* and gas pressure acting on a diaphragm *D*. An increase in gas demand will decrease the pressure in the main and on the right-hand side of diaphragm *D* causing it to move the jet pipe slightly to the right. This will increase the oil pressure on the left-hand end of piston *P* and decrease it on the right hand end. The piston will then move to open the damper to reestablish normal pressure in the main. When this occurs, diaphragm *D* will return jet pipe *P* to neutral and equalize oil pressure on the piston to stop further motion of the damper. Pressure that the regulator will maintain in the gas main can be adjusted by spring *S*.

The regulator Fig. 2 is similar to the design used for keeping constant pressure in a furnace. In this service there is a lag between change in furnace pressure and movement of a damper or change in fan speed to restore the pressure to normal. It is therefore necessary to provide means for modifying the effect of the regulatory impulse, before the latter is completely operative, to make the regulator more stable, and is accomplished with a hydraulic stabilizer, Fig. 1. This regulator is the same as in Fig. 2 except the hydraulic stabilizer has been added and the diaphragm *D* is subjected to furnace pressure.

A decrease in furnace pressure Fig. 1 will cause diaphragm *D* and jet pipe *P* to move slightly to the right. Oil pressure will be increased on the top side of piston P_1 and it starts down to open the damper. Oil from the bottom side of piston P_1 is forced into the stabilizing cylinder, moves piston P_2 toward the right and compresses spring S_1. At the same time, through lever *L*, tension is increased in spring *S* to return jet pipe *P* to neutral to stop piston P_1. When piston P_1 stops piston P_2 is off center against tension of spring S_1, which returns it to mid-position by forcing oil through bypass *B*. This also puts normal tension in spring S_1 and if furnace pressure has returned to normal the jet pipe will remain in the neutral, stable conditions having been established. If the adjustment of furnace pressure has not been sufficient, then a further correction is made.

In the master regulator, steam from the header acts on a sylphon balanced against weight *W*, Fig. 3. The weigh beam controls movement of jet pipe, *P* by a linkage. Compensation of jet-pipe movement is by master pressure on diaphragm *D* through a linkage and an adjustable fulcrum. Air instead of oil is used in the jet acting on one orifice only, which connects to the master-loading line.

An increase in steam pressure will move the sylphon downward and the jet pipe away from the orifice to reduce the loading pressure to the boiler regulators. The reduced loading pressure acts on diaphragm *D* to counteract the action of steam pressure on the sylphon and again put the regulator in equilibrium.

Relation between steam pressure and loading pressure may be adjusted by a movable fulcrum *F*,

without taking regulator from service.

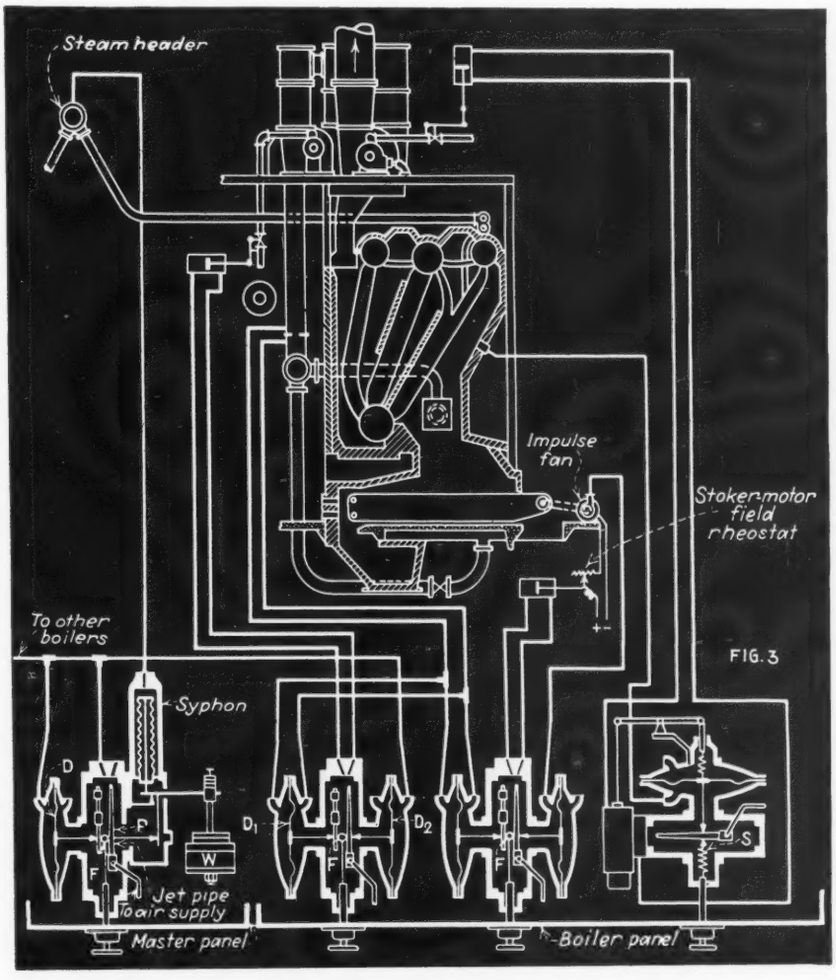
On the air-flow regulator, differential pressure from an orifice in the air duct is connected across diaphragm D_1 with the highest pressure connection on the outside. Loading pressure is connected to outside of diaphragm D_2, so that draft is balanced against loading pressure, with both acting against the jet pipe. A change in loading pressure will unbalance the regulator and cause the jet pipe to move from neutral to operate the power cylinder and correct the draft until the regulator is again in balance. The regulator for coal feed is similar to that for air flow, except in the manner connecting it into the system.

In Fig. 3 the control is applied to one boiler of a bank fired by travelling-grate stokers. Draft is provided by forced-and-induced-draft fans under control of an air-flow controller and a furnace-pressure regulator respectively. An increase in load will cause a decrease in steam pressure and weight W on the master regulator will drop slightly and deflect the jet pipe to the left to increase the loading pressure. The increase in loading pressure is transmitted to the diaphragm D_2 of the air-flow controller and deflects its jet pipe to the left. This causes the power cylinder to start opening the forced-draft-fan turbine throttle valve to increase the air flow. Loading pressure on diaphragm D_2 of the air controller is balanced against air pressure in the forced-draft duct on diaphragm D_1, so that for a definite increase in the former there will be a proportional increase in the latter to bring the controller to neutral.

The left-hand diaphragm of the fuel-feed regulator is loaded by the differential across the forced-draft duct orifice and will function to move the jet pipe of this controller to the right. This will cause its power cylinder to function and cut resistance into stoker-motor field to increase the rate of fuel feed. In the fuel-feed controller the right-hand diaphragm is connected to the suction of a small fan driven by the stoker motor. When the stoker speed increases suction on the fuel-feed controller diaphragm increases to balance the draft pressure and put the controller in neutral. The two forces, forced-draft and impulse-fan suction, vary as the law of squares, therefore will maintain a constant ratio between air flow and fuel feed. Increasing the forced-draft raises furnace pressure which acts on the furnace-pressure regulator to increase induced-draft fan speed and restore this pressure to normal.

In plant practice, elements are provided so that operation may be readily changed from automatic to manual and for operating part of the boilers in a bank on base load and part to take load swings.

Fig. 3—Type of regulators in Fig. 2 applied to control of a chain-grate-stoker fired boiler equipped with steam-driven forced-and induced-draft fans



Carrick

• Automatic combustion-control systems may be divided into two general classes: those that use air or a fluid to transmit the master impulses, and systems in which this is done electrically. It is in the latter class that the Carrick control of the Hays Corporation system belongs.

In the master regulator, Fig. 1, header pressure on sylphon S is balanced against spring-loaded lever L. The right-hand end of L is connected through a linkage to bellcrank B, pivoted at P. At the lower end of the bellcrank are two permanent magnets M and M_1 with a vertical mercury switch in front of each. The switches are fixed and are so designed that their contacts are closed by a small piece of magnetic material mounted on a movable armature inside the switch tube. A load indicator, not shown, on the front of the master is operated from crank C, which connects to the motor operator on the back of the master.

If steam pressure decreases, sylphon S expands and allows lever L to drop slightly and through bellcrank B will swing permanent magnet M toward mercury switch W. Contacts of this switch close, and through a relay start the motor operator to turn crank C_1, counterclockwise to lift floating lever L_1, swinging the permanent magnets to

neutral and releasing switch W to stop the operator. The motor operator also connects to the fuel-feed and air-flow controls, and they are positioned to increase combustion rate.

The boiler loader or air-flow controller, Fig. 2, comprises a draft measuring element connected across the boiler by the two connections, B and B. A cam C so shaped that it eliminates the square-root factor between differential draft and rate of air flow, is connected to the master motor operator. Arm A, pivoted at P and carrying permanent magnets M and M_1, connects to diaphragm D of the air-flow element, and is free to move according to the draft differential drop across the boiler. Decreased steam pressure causes motor operator on the master to turn cam C clockwise, and through lever L and spring S swings magnet M toward mercury switch W. This switch closes to operate the stack damper or induced-draft fan controller to increase the combustion-air flow. Increased draft across the boiler acting on diaphragm D of the draft-measuring element pulls arm A to neutral and opens switch W to stop the induced-draft adjustment. An increase in steam pressure will cause the master motor operator to turn cam C counter-clockwise to produce a decrease in draft, by swinging arm A to the right. Air flow can be changed independently of fuel feed by an adjusting screw not shown. Pointers are provided to show how far the fuel-air ratio is off normal and the position of the air controller.

The fuel-feed control, Fig. 3, is similar to the air controller except in compensation. A simple draft element with a slack-leather diaphragm D connects to the suction of a tachometer blower (small fan) driven from the fuel feeder. Arm A of the controller connects to diaphragm D, is pivoted at P, and is connected to lever L by a spring. For an increase in load, the master motor operator turns cam C clockwise, which moves arm A to the left and closes mercury switch W to increase fuel feed and tachometer-blower speed. The latter increases the suction on the diaphragm, which swings arm A to the right, opening mercury switch W to stop the coal-feed change. A demand for less fuel causes opposite operations.

The furnace-draft regulator, Fig. 4, functions on a change in furnace draft, independently of the master. Slack-leather draft element D connects to the furnace. Arm A carrying permanent magnets is pivoted at P. A decrease in furnace pressure, such as occurs when the stack damper starts to open, causes the magnets to swing to the right and close switch W_1. This switch puts the forced-draft operator to work opening the damper or speeding up the fan to correct furnace draft to new load requirements.

Fig. 5 is a simple layout of this combustion-control system applied to a stoker-fired boiler. The various elements to control air flow may be regulated by either electrical or hydraulic operators.

As shown in Fig. 5, various elements of the combustion-control system are built into meter-size cases and mounted on the boiler panel with the metering elements. In the figure, assume that steam pressure increases, indicating a decrease in load. This will cause the master controller to decrease combustion rate by causing the boiler loader to close the stack damper and the fuel-feed control to slow down the stoker. Connections from the top of the second and third passes lead back to compensate the boiler loader, and a connection from the tachometer blower compensates the fuel-feeder controller, as ex-

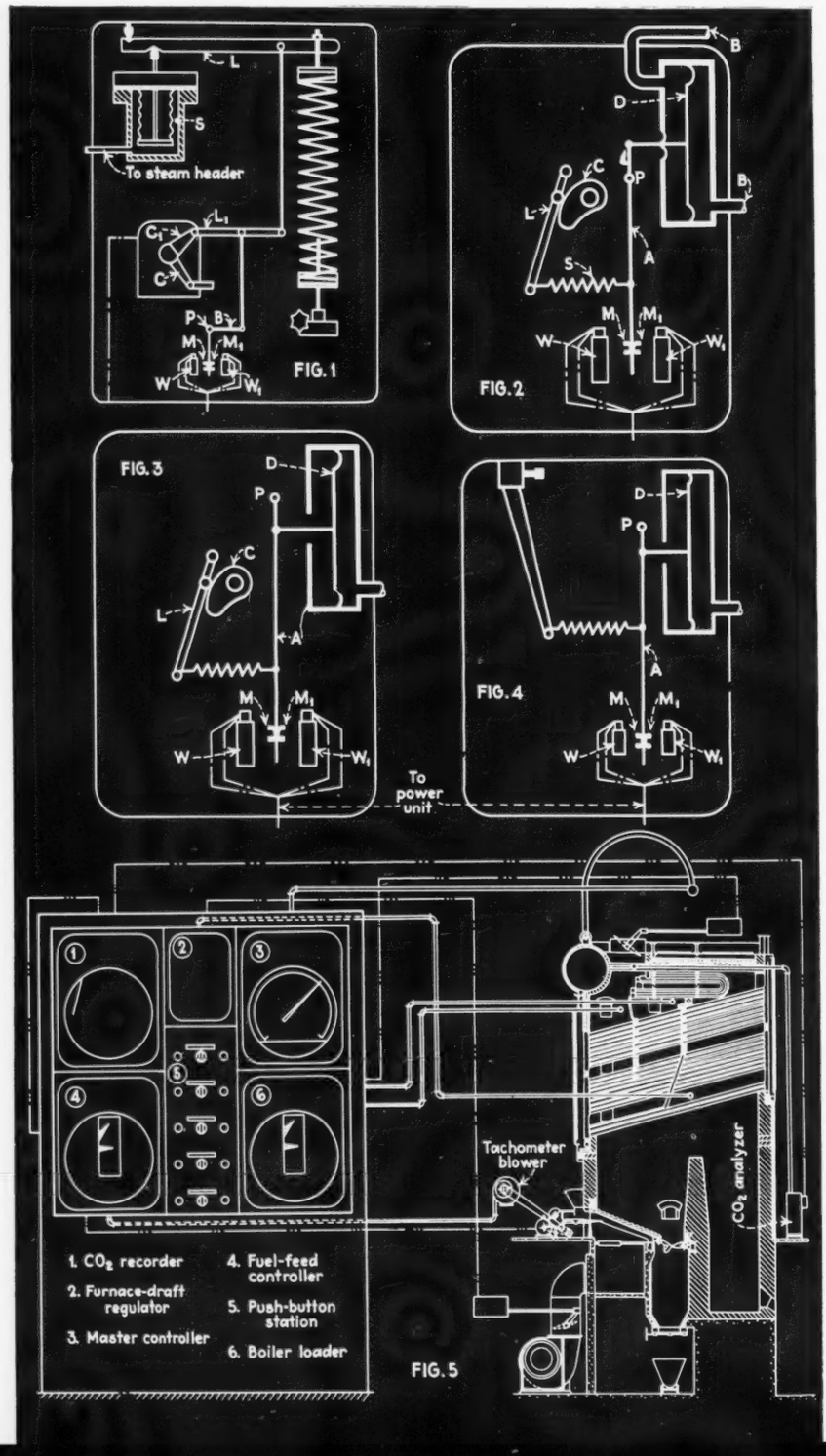


Fig. 1—Simplified diagram of the Carrick master control. Figs. 2 and 3—Air-flow control, or boiler loader and fuel-feed control respectively used in conjunction with the master control, Fig. 1. Fig. 4—Furnace-draft control maintains constant draft independent of operation of the rest of the combustion-control system. Fig. 5—Control elements, Figs. 1 to 4, applied for operating a stoker-fired boiler

plained previously for Figs. 2 and 3.

A furnace-draft regulator connected into the combustion chamber responds to changes in draft. Variations in draft are accurately measured, and a small electrical impulse is sent to the double-solenoid operated 4-way valve at the windbox damper operator, which adjusts the damper to reestablish correct furnace pressure.

An automatic CO_2 analyzer tests flue gas and delivers a measured impulse, proportional to the percent CO_2, to the CO_2 compensator and recorder. Should the percent CO_2 vary from that for which the compensator is adjusted, it adjusts contacts on the fuel-feed controller to regulate stoker speed to gradually correct CO_2 to the desired value.

A pushbutton station in the center of the panel permits the boiler or group of boilers to be switched from automatic to manual control. When on manual control, the combustion process can be increased or decreased simply by pressing a pushbutton.

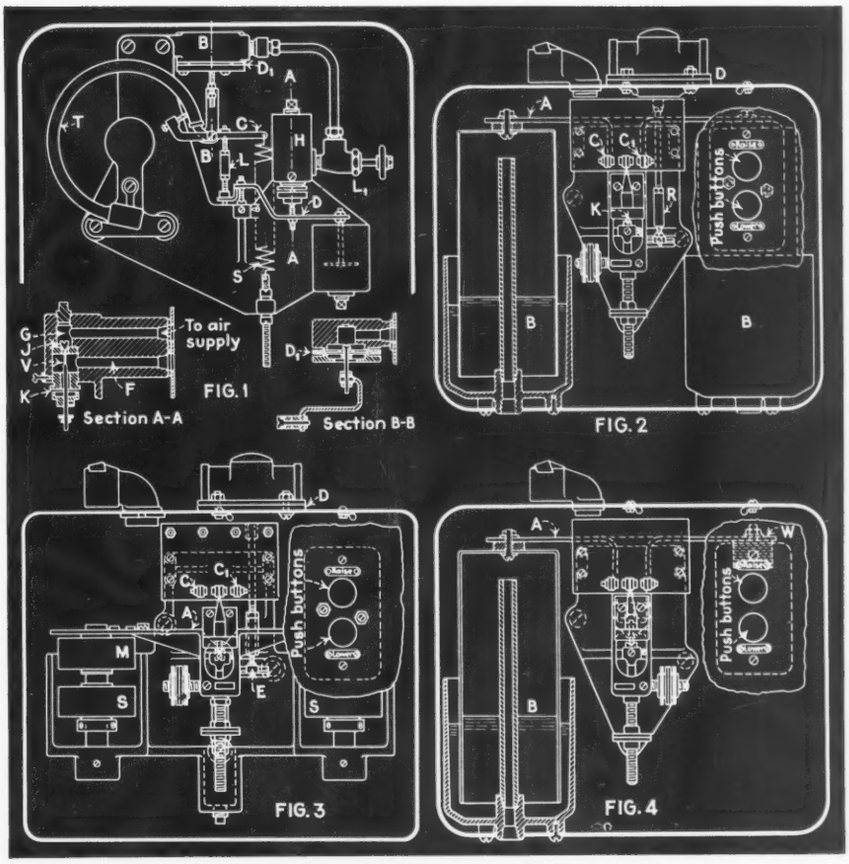


Fig. 1—Master regulator for Leeds & Northrup system of automatic combustion control. Fig. 2—Air-flow control closes contacts for electric operator to adjust fan speed or move dampers. Fig. 3—Fuel-feed controller is of the electrical type operated by master pressure and compensated by current from a tachometer generator. Fig. 4—Furnace draft controller closes contacts, when furnace draft varies, to energize an electrical operator to return conditions to normal

Leeds & Northrup

• Modern power-plant practice requires that boilers be operated at high efficiency, that furnace conditions be uniform and that steam pressure be held practically constant, all of which dictates automatic control of the combustion process. The Leeds & Northrup Co. system for doing this job is of the electro-pneumatic type, employing a variable air-loading pressure for transmitting the master-control action to the individual controls, together with electric-motor drive units on the regulated elements.

The master controller, Fig. 1, comprises Bourdon tube T connected to the steam header. The free end of this tube connects through arm C and link L to lever D. Steam pressure in the tube is balanced against tension of spring S. Housing H contains the bleed and throttle valve. This valve connects to arm D and as it is moved up or down by steam-pressure changes in the Bourdon tube, regulates the master air-pressure impulses.

A cross-section through the bleed valve is shown as section A-A. Control air-supply pressure is admitted to chamber G, and space F connects to the air-loading line to the control equipment. Valve V throttles at J and bleeds at K. If valve V moves upward, the throttle opening increases and the bleed opening decreases, consequently loading pressure rises. Downward movement of valve V reduces throttle opening J and increases the bleed passage to reduce air-loading pressure. From this it is seen that as valve V is moved up or down as steam pressure changes in the Bourdon tube, corresponding air-pressure impulses are sent out to the combustion-control equipment.

Action of bleed valve V is such as to give a slightly lower steam pressure at full load than at reduced capacity. Where it is desirable to have constant steam pressure, compensator B is used, in which diaphragm D_1 connects to the free end of the Bourdon tube and has master loading pressure admitted above it. A drop in steam pressure tends to cause the Bourdon tube to move downward and in so doing adjusts valve H to increase the master loading pressure. An increase in master loading pressure above the compensator diaphragm will act down and tend to intensify the action of decreased steam pressure in the Bourdon tube. This action produces an increase in master air-loading pressure to speed up combustion rate sufficiently to bring steam pressure back to normal. By means of throttle valve L_1 and an air capacity tank not shown, action of the compensator can be regulated so that steam pressure is returned gradually to normal.

The air-flow controller comprises two oil-sealed bells B, Fig. 2, subjected to draft differential across the boiler. Bells B connect to the ends of arm A, pivoted on a knife edge K, and has master loading pressure on a diaphragm D applied through rod R to counteract changes in draft across the boiler. Two contacts, C and C_1 are closed and opened by movement of arm A to increase or decrease air flow by operating the air flow control drive.

The fuel-feed controller, Fig. 3, operates on a principle similar to that of the air-flow controller, except that stationary electrical coils S and movable coils M have been substituted for

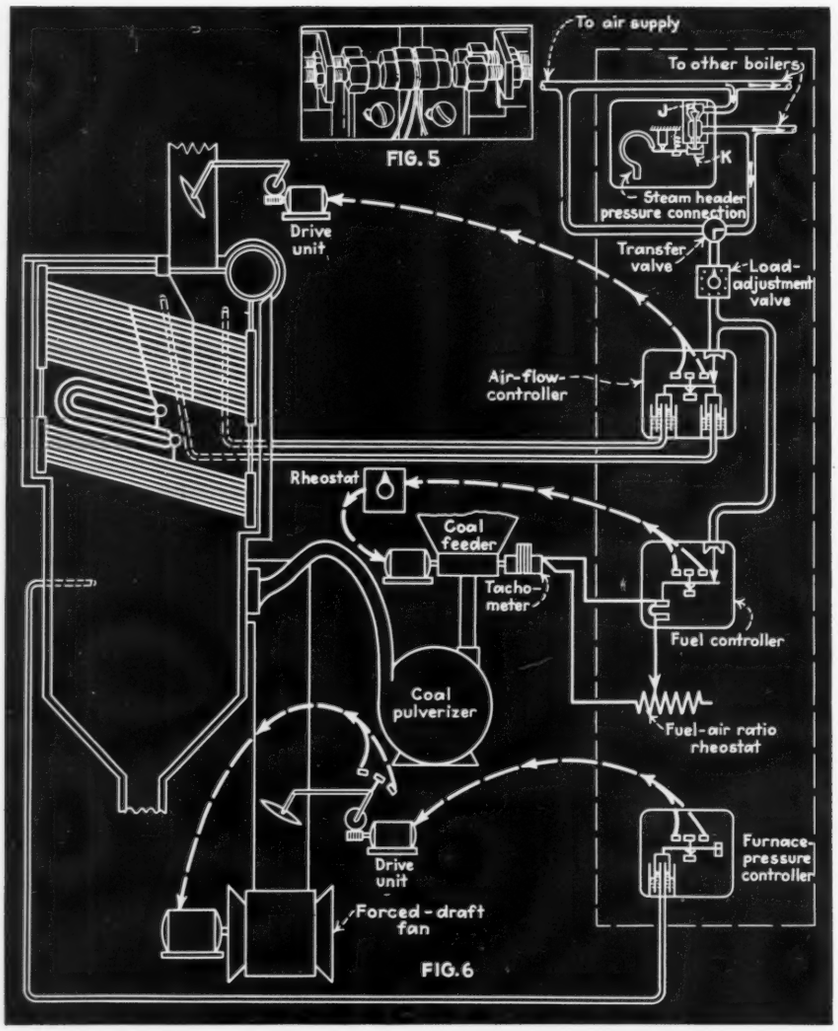


Fig. 5—Double contacts for fuel-feed, air-flow and furnace-draft regulators, Figs. 2 to 4. Fig. 6—Regulators, Figs. 1 to 4, controlling a pulverized-coal-fired boiler

the oil-sealed bells. The coils are in series and connect to an electrical tachometer driven by the fuel feeder. These coils are so connected that their magnetic forces produce an effort that tends to rotate arm *A* counter-clockwise. This action is balanced against master loading pressure, or diaphragm *D* connected to arm *A* at *E*. An increase in loading pressure closes contact C_1 and speeds up the fuel feeder, which also increases the voltage of the electrical tachometer. The latter will increase current in coils *S* and *M* to increase the force acting against the master loading pressure and bring arm *A* into balance.

The furnace-pressure controller, Fig. 4, has only one oil-sealed bell *B* connected to furnace pressure, balanced against a weight *W* on the right-hand end of arm *A*. This arm carries contacts for controlling draft-equipment to maintain predetermined furnace draft.

Each individual draft and fuel-feed controller is equipped with two sets of contacts, Fig. 5. One set effects a slow rate of control action in response to a small unbalance at the corresponding controller, the other produces rapid control action in response to large changes in combustion rate. This type of variable response serves to provide control action proportional to changes in demand without hunting.

Fig. 6 shows the various regulators connected to control a pulverized-coal-fired boiler. In this setup, the air-flow controller adjusts the stack damper, and the furnace-draft regulator adjusts the forced-draft damper and controls forced-draft fan speed to maintain constant furnace draft. Air for the master control is supplied through a reducing valve at about 10 in. of water. Loading pressure inside throttle valve *J* is controlled by the position of bleed valve *K*.

A decrease in steam pressure, indicating a demand for more steam, will cause the Bourdon tube to contract slightly and reduce bleed valve *K* and increase throttle valve *J* ports. This will raise the master loading pressure on the air and the fuel-feed controllers. Increased loading on these controllers causes their arms to tilt in a clockwise direction and close their right-hand contacts. The air controller starts its motor drive unit to open the stack damper for increased draft. This causes a decrease in pressure under the left-hand and an increase under the right-hand bell which tends to turn the arm in a counter-clockwise direction to put the control in equilibrium again.

The fuel controller increases the speed of the coal feeder until the tachometer voltage reaches a value to produce sufficient counter-clockwise force on the controller arm to put it in equilibrium, when the contact opens to stop fuel-feed adjustment.

Opening the stack damper causes a slight decrease in furnace pressure momentarily, and the furnace-pressure controller closes its left-hand contact and starts the forced-draft drive unit, opening the damper to keep furnace pressure normal, when the controller will again be in balance and its contacts open. When the damper has opened or closed to a certain position it closes contacts that start to adjust the speed of the forced-draft fan then the damper control acts as a vernier adjustment on fan speed to maintain constant furnace pressure.

A transfer valve is provided to change from master automatic or to individual automatic, the latter for base-load control. When the transfer valve is in the latter position, load taken by the boiler will depend upon the setting of the load-adjustment valve. This valve is used when operating one boiler of a group on base load. The control system also includes many refinements (not shown) to give a wide degree of flexibility of operation on either automatic or manual control.

As shown in Figs. 1 to 4, all control units are in meter-size cases and can be mounted on the boiler panel with the other meters. As generally arranged, the master, air-flow, fuel-feed and furnace-draft regulators are mounted on the same panel along with a load-adjustment valve, fuel-air rheostat transfer valve and selector switch.

Automatic or pushbutton control may be had with the selector by

throwing it to either one of two positions. When the selector is in pushbutton position, circuits to regulator contacts are switched to pushbuttons in regulator covers, Figs. 2 to 4. Then each drive unit may be adjusted at will from the pushbuttons. Setting of the load-adjustment valve determines the proportional boiler loading of each boiler in a group. The fuel-air ratio control is a rheostat in series with the tachometer generator driven by the fuel feeder.

Brooke

• It is general practice to use a master pressure in combustion-control systems applied to two or more boilers. Where this pressure is used to operate power units, it must be at least 30 lb. per sq. in. In the Brooke Engineering Co. system, since each regulator is driven by a reversing motor, master pressure is a pilot only.

Two blowers, one a spare, are mounted behind the master panel, as in Fig. 1. Each blower is driven by a 0.25-hp. motor and supplies air at approximately 1.5-in. water-column pressure. This air is delivered through an orifice and two valves to atmosphere. Valve *H* is used when the plant is on hand control and valve *M* is operated by the master-steam-pressure regulator. Pressure ahead of valve *M* is piped to each boiler-control panel, is the master-impulse pressure and acts on both fuel and air regulators. Hand adjusting valves on boiler panels are provided to change fuel-air-ratio when desired.

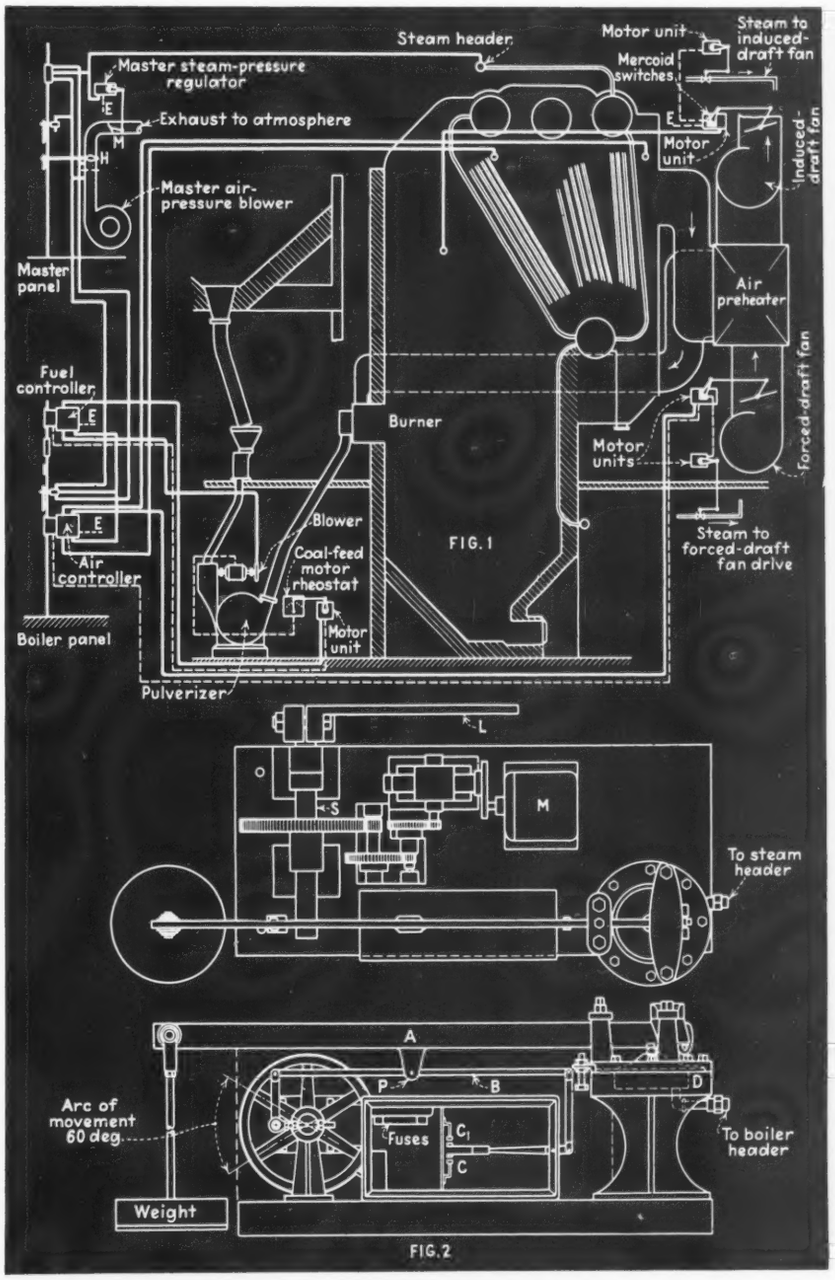
In the master steam-pressure regulator, Fig. 2, boiler-header pressure under diaphragm *D* is balanced against a weight arm *A* supported on a knife edge. An increase in steam pressure, which indicates a decrease in load, causes the arm to rise and carries with it movable pivot *P*. By means of interconnecting linkages this movement causes contact *C* to close and energize motor *M*, which through a gear train starts shaft *S* turning clockwise. This motion lifts the left-hand end of arm *B* and opens contact *C* to stop the motor. Movement of shaft *S* through lever *L* moves valve *M*, Fig. 1, toward the open position and causes the control to adjust fuel and air to the new load conditions. If the pressure continues to rise, contact *C* will again close to cause the control system to further slow up of the combustion process.

With an increasing load, steam pressure will decrease slightly, causing the master controller to close contact C_1, which will reverse the direction of motor *M*. The motor will then move valve *M* toward the closed position to increase loading pressure and speed up combustion.

The furnace-pressure regulator of Fig. 3 has the underside of its diaphragm *D* piped to the furnace. Any change in furnace pressure causes the diaphragm to move and close contact *C* or C_1 to energize motor *A*. This motor through a gear train moves the operating arm to adjust draft-damper position and change draft-fan speed to correct the furnace pressure. As furnace pressure is corrected, the diaphragm comes back to normal and opens the contact to stop the motor. A small fan *F* on the motor shaft puts a compensating pressure on top of diaphragm *D*, through pipe *P*, to prevent overtravel. This pressure is plus when the contact is correcting for an increase in furnace pressure and minus when the control is correcting for a decrease in furnace pressure. From this it is seen that the compensation pressure always acts to put the regulator in balance.

Fuel controller and air controller

Fig. 1—Brooke system of automatic combustion control applied to a pulverized-coal-fired boiler. Fig. 2—Master controller comprises a weight-loaded diaphragm, contacts and a motor-driven operating lever



are alike except in application. This unit, Fig. 4, comprises two oil-sealed bells B and B_1, connected together and pivoted at a point between them. The pivot shaft connects in such a way that movement of the bells will close and open contacts C and C_1, to start and stop compensating fan motor M. A second set of contacts at C and C_1 but not shown, are for operating the fuel-feed or the air-flow control equipment. On other arrangements of this equipment the compensating fan is mounted directly on the control-motor shaft, as in Fig. 3.

A diagrammatical layout of the air controller is shown in Fig. 5. Left-hand bell B_1 is subjected to differential pressure across the boiler, and bell B connects to master pressure and the compensating pressure of the motor unit. As previously shown, an increase in steam pressure causes a decrease in master pressure to decrease combustion rate. In Fig. 5, a decrease of master pressure will cause bell B to move downward to close top contact C and start the motor unit closing the inlet damper. This action reduces differential pressure acting on bell B_1 to put the regulator in balance and open contact C. Immediately when the control motor starts, its fan puts a compensating negative pressure on top of bell B to help balance the regulator, open contact C, and stop the control motor. The effects of the compensating pressure is to make the adjustment in steps so that there will be no overtravel. An increase in master pressure will operate the controller to open the damper.

Fig. 6 shows the controller connected to regulate pulverized-coal feed. In this case, bell B_1 is connected to master and compensating pressures and bell B to a small blower on the end of the feeder-motor shaft. Now, a decrease in master pressure causes contact C to close and starts the motor unit operating to slow down the coal-feeder motor. The compensating fan on the motor unit puts a negative pressure above bell B_1 and the fan on the feeder motor decreases the pressure under bell B to put the regulator in balance again and stop the control motor.

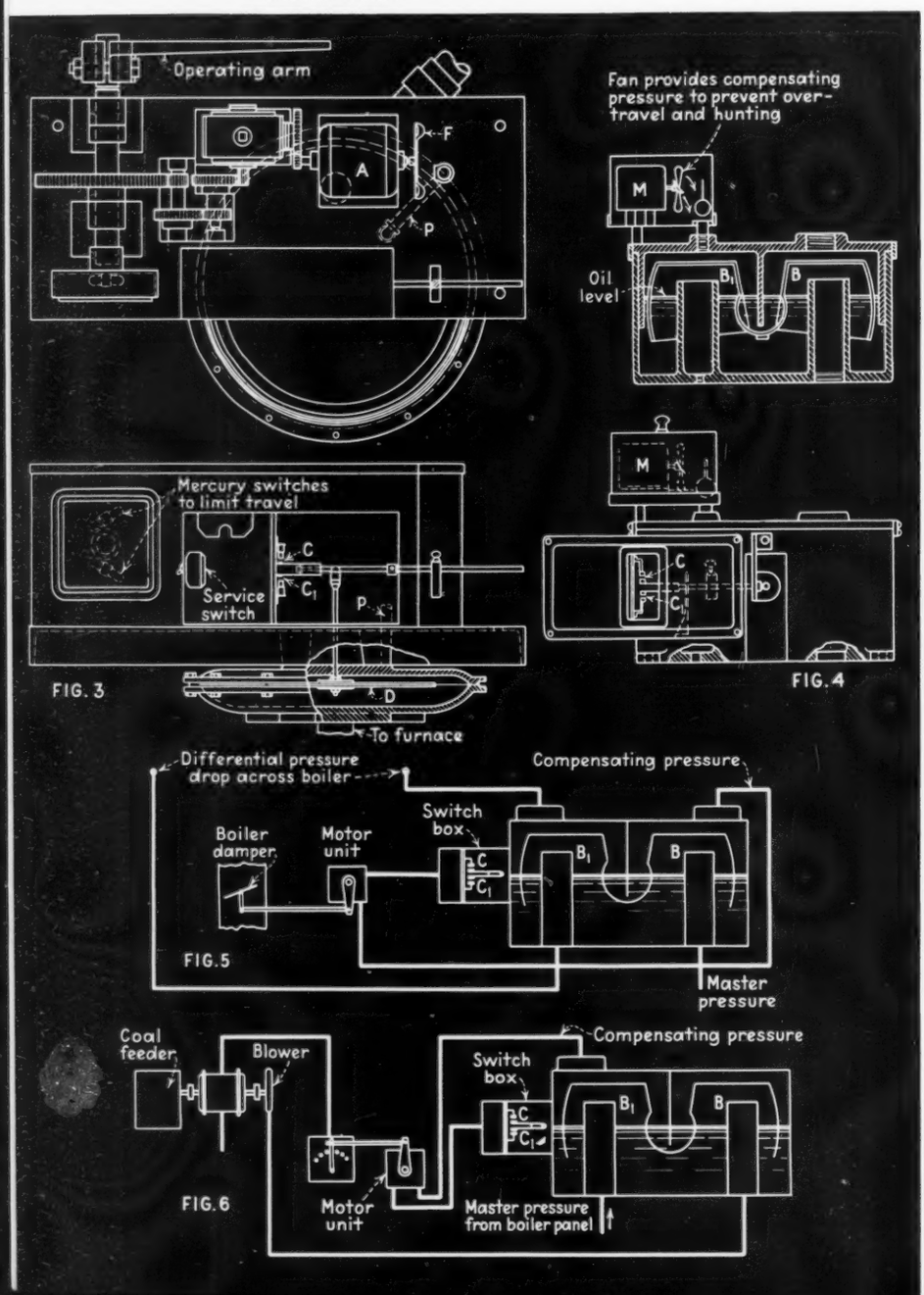
In the air controller, master pressure is balanced against the differential across the boiler which varies with the square of the gas-flow velocity. On the fuel feeder, master pressure is balanced by that of a fan on the feeder, the pressure of which varies as the square of the speed. In this way fuel and air are measured, and balanced against each other by the same law and at the same time are responsive to load changes as indicated by the master.

A complete layout of this combustion-control system is shown in Fig. 1, for a pulverized-coal-fired boiler. A master panel is provided for the group of boilers and a boiler panel for each boiler in the group. Operation of the system is as follows:

A change in steam pressure causes the master regulator to adjust valve M to change loading pressure. This loading pressure acts on the fuel and air controllers on the boiler panel. These controllers start the coal-feed and forced-draft motor units to adjust fuel and air for the new load on the boiler. The compensating fan on the feeder motor is connected back into the fuel feeder, differential across the boiler is connected back to the air controller, and a compensation-pressure line leads back to the controllers. These connections are the same as for Figs. 5 and 6, and action of these controls to adjust fuel feed and air flow is the same. A change in forced draft changes furnace pressure, which acts on the induced-draft motor unit to adjust the stack damper or induced-draft fan speed to correct furnace pressure.

In this installation the forced-and induced-draft fans are steam driven and have their speed controlled by motor units connected to their throttle valves. These motor units are controlled by mercoid switches in the damper controllers. For example, when the forced-draft damper approaches full-open position a mercoid switch closes on it that starts

Fig. 3—Furnace-draft controller. Fig. 4—Operator for air-flow or fuel-feed control. Fig. 5—Operator, Fig. 4, connected for air-flow control. Fig. 6—Operator, Fig. 4, applied to fuel-feed control



the forced-draft-fan controller opening the throttle valve to speed up the fan. When fan speed begins to increase furnace-draft, differential across the boiler is increased, and these controllers start correcting this condition. As the forced-draft damper moves toward the closed position, it opens the mercoid switch and stops the fan throttle-valve controller. Then when proper draft conditions have again been established, the other controller comes to rest. The reverse operation takes place when the damper reaches a predetermined position toward closing.

Cash

• The combustion-control system of the A. W. Cash Co., as applied to a forced-draft stoker-fired installation, is shown in Fig. 1. The heart of this system is the master controller, receiving its actuating impulse from variations in header steam pressure. This controller simultaneously adjusts stoker speed and fan speed, and through another controller regulates forced-draft air pressure to maintain correct combustion conditions. Furnace-draft pressure is regulated separately by a controller operating the uptake damper.

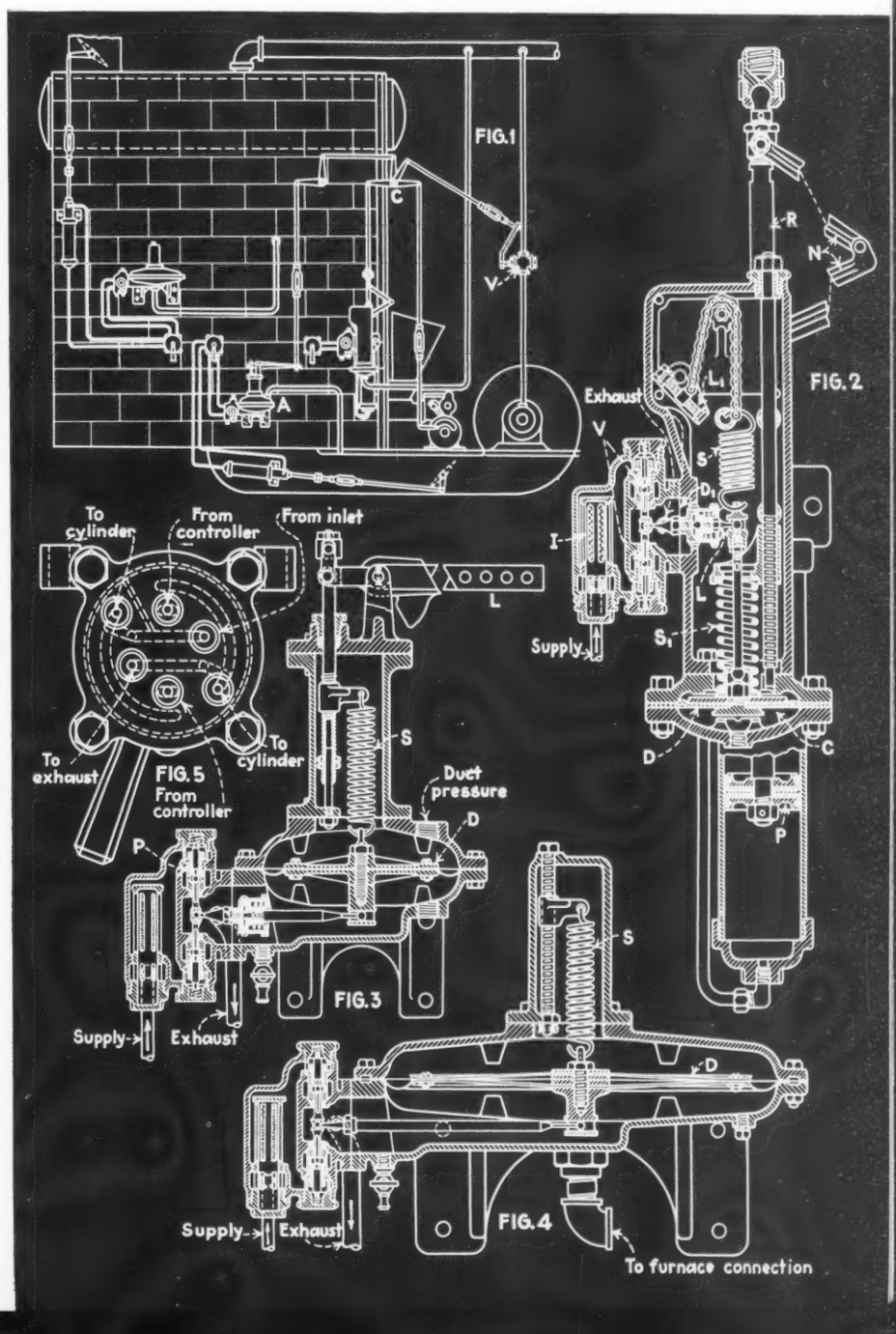
Header steam pressure is piped to chamber C of the master controller, Fig. 2, where it is opposed by spring-loaded diaphragm D. Movement of the diaphragm is transmitted to pilot valve V through the full-floating ball contact lever L fulcrumed on diaphragm D_1. Operating fluid which may be water, oil or air under pressure enters the valve chamber through strainer I and through ports to the top and bottom ends of valve V. Opposite the balls on the valve stem are ports connected to the top and bottom of the power cylinder. When the valve is moved upward the top ball seats and closes off pressure-fluid flow to bottom end of the power cylinder and opens the port on its under side to let fluid flow from the top end of the cylinder to exhaust. At the same time the bottom ball seats to close off the top end of the cylinder from exhaust and opens its bottom port to admit pressure above piston P, and the piston moves downward. Moving the pilot valve downward produces an effect opposite to that described in the foregoing.

Linkage N connects piston rod R to compensating lever L_1, which in turn is connected by the roller chain to compensating spring S that is opposed by compression spring S_1 on diaphragm D.

When proper operating conditions exist, the control is at rest. Assume a decrease in steam pressure, indicating an increase in demand. This will cause diaphragm D to deflect downward slightly, and through lever L move pilot valve V upward. This admits pressure fluid above piston P and exhausts from the lower end of the cylinder, as previously explained, and the piston starts to move downward. When this occurs, compensating lever L_1 turns clockwise and increases tension in spring S. When tension equals the decreased loading under diaphragm D, it returns pilot valve V to neutral, and motion of power piston P stops.

For controlling the forced-draft damper, Fig. 1, a regulator, Fig. 3, is used, lever L of which connects to the master through linkages. Diaphragm D of this regulator is connected to lever L by spring S and has forced-draft pressure applied above it. Movement of the diaphragm actuates a pilot valve P similar to that of the master controller, Fig. 2. If the right-hand end of lever L is lowered, diaphragm D will be lifted, which will open the bottom port of pilot valve P to exhaust and open the top port to admit pressure fluid to the damper power cylinder. The power cylinder then functions to increase the

Fig. 1—Cash system of automatic combustion control applied to a stoker-fired boiler. Fig. 2—Master regulator and power cylinder in a single unit. Fig. 3—Air-flow regulator has lever L connected mechanically to the master. Fig. 4—Furnace-pressure regulator operates a pilot valve to control a damper power unit. Fig. 5—Hand-control valve used with air-flow, furnace-pressure and master regulators



draft, which, when it reaches a predetermined value, brings diaphragm *D* back to neutral against the tension of spring *S* and stops further movement of the power piston.

Furnace draft in Fig. 1 is controlled independently of the master by the regulator, Fig. 4, which controls the flow of pressure fluid to the uptake-damper power cylinder. Furnace draft under diaphragm *D* is balanced against tension of spring *S*. A change in draft pressure causes the diaphragm to move and actuate pilot valve *P* and cause the power cylinder to adjust the damper to return furnace pressure to normal. When this condition is established, diaphragm *D* returns to neutral and positions the pilot valve to stop further movement of the power cylinder.

A hand-control valve, Fig. 5, is provided on the master, the air-flow regulator and the damper regulator, Fig. 1. On the master, the hand-control valve is used to adjust combustion rate, as if a change in steam pressure had occurred. On the forced-draft and furnace regulators, the hand-control valve permits damper position to be adjusted independently of the master. By moving the hand-valve handle, the pilot valve on the regulator can be bypassed and the operating-cylinder piston moved to any desired position by pressure fluid.

In Fig. 1, a drop in steam pressure will cause the master regulator to function and start moving the power cylinder piston down, as explained for Fig. 2. When the power-piston reaches a position corresponding to steam pressure, the compensation centers the pilot valve to stop the piston. Downward movement of the piston turns bell cranks *C* counter-clockwise. Valve *V* is also opened to increase speed of the forced-draft fan, stoker speed is increased and the pilot valve of regulator *A* is positioned to cause the power cylinder to open the forced-draft damper to a new position. Increased draft pressure under the stoker, acting on the diaphragm, returns the pilot valve to neutral to stop the damper, as explained for Fig. 3. The change in furnace pressure causes the furnace-draft regulator to adjust the uptake damper to correct this condition.

While a stoked-fired installation has been described, combinations of the controllers can be used for other kinds of fuel and fuel-burning arrangements. The master controller may be used to control a group of boilers as well as a single unit, Fig. 1.

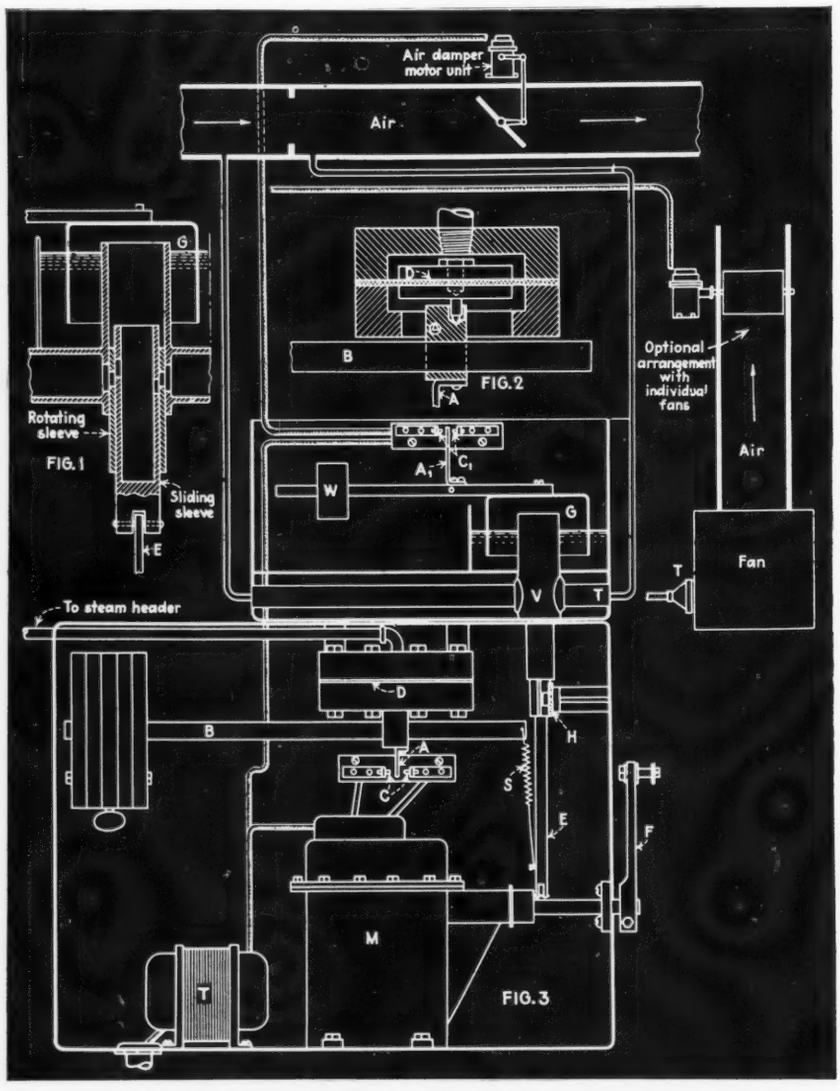
Shallcross

• One automatic combustion-control system of Shallcross Control Systems, Inc. combines the master, fuel-feed and air flow-regulators in a unit, with electrical power units for adjusting combustion, Figs. 1 to 3. This arrangement is that used for a single boiler. For a group of boilers, the master is separate from the fuel-feed and air-flow units for each boiler. The master controller is similar to that in Fig. 1, but, instead of being connected to the air-flow and fuel-feed controls mechanically, it is coupled to a Selsyn sending unit. This Selsyn sender is connected to Selsyn receivers on the fuel-feed and air-flow controls.

When steam pressure changes, the master adjusts its Selsyn, and those on the fuel-feed and air-flow controls take corresponding positions to adjust combustion rate to the new steam demand. Furnace pressure is maintained constant by a separate regulator in each system. Provisions are made for switching from automatic to manual control. The latter may be done from a push-button station at the master or from individual stations for each boiler, or each control may be adjusted individually to obtain the desired fuel-air ratio.

In the master, Fig. 3, steam-header pressure on diaphragm *D* is balanced

Fig. 1—Cross-section of variable-orifice valve for Shallcross combustion-control systems. Fig. 2—Shows how weigh beam B, Fig. 3, is fulcrumed and acted upon by diaphragm D. Fig. 3—Combustion-control system includes master, fuel-feed and air-flow regulators in a unit



against weigh beam B fulcrumed as in Fig. 1. This beam carries arm A to complete an electrical circuit when resting on either of two contacts C. These contacts actuate reversing motor M energized by 25-volt current from transformer T. This unit comprises a motor with speed-reducing gearing sealed in oil. On the right-hand end of the motor shaft, crank F connects to the fuel-feed drive adjustment, varied to suit type of fuel.

Stabilizing spring S between a small crank on the motor shaft and the weigh beam prevents overtravel or hunting of the control. This compensating spring is light and is used to bring the contact arm A to neutral when the motor has moved crank F a definite amount, proportional to the steam pressure change. The total extra load on the weigh beam resulting from a complete 90-deg. motion of crank F and extension of spring S is only 2% of the plant steam pressure.

The air-flow regulator comprises gasometer G supported on a weigh beam with counterweight W, Fig. 3. This beam supports arm A_1 between two contacts C_1, which control the air-damper motor drive. Furnace air is measured by differential across an orifice in the air duct or by air suction of a measuring tube in the suction of a fan, connected to a variable-orifice valve in the tube under the gasometer bell that causes it to function and adjust air flow in proper ratio to coal feed, as determined by the master.

A cross-section of the gasometer variable-orifice valve is shown in Fig. 1. The inside sleeve connects to a crank on the shaft of motor M by rod E and moves up and down with this crank. As the internal sliding sleeve moves down on decreased pressure, corresponding to increased steam load, the right-hand port is closed and the left-hand port opened. This means that the suction under the gasometer is reduced, causing it to increase air flow by opening the damper or increasing fan speed to produce necessary suction under the gasometer bell to balance the weigh beam and stop the air-flow adjustment. In this way, the air flow is made to increase in correct proportion to coal feed, and vice versa.

The middle or rotating sleeve in this valve is adjustment H on the master, Fig. 3. Rotating this sleeve opens or closes the right-hand port with a reverse action on the left-hand one. Therefore, as the ports are opened or closed by the rotating sleeve, the sliding sleeve will move a greater or less amount in proportion to coal-feed change to make the air-flow adjustment. The rotating sleeve then becomes a fuel-air ratio adjustment on the control.

To follow through operation of the controller, assume a decrease in steam pressure, indicating a demand for a greater heat input. Weigh beam B will take a lower position, closing the right-hand C contact and starting motor unit M to increase fuel feed. This adjustment continues until increased tension in spring S is sufficient to put beam B in balance and open contact C. Rotation of the motor also lowers the sleeve in variable-orifice valve V. As previously explained, this action reduces suction under the gasometer and it closes one contact to increase air flow by damper or fan-speed adjustment in proportion to coal feed. When this condition obtains, a suction has been produced under the gasometer to put it into balance and open its contact. Furnace-draft pressure is held constant by a separate regulator.

ACKNOWLEDGMENTS

Other manufacturers of combustion-control equipment, whose units are not described herein, include the Mason-Neilan Regulator Co., Denver Fire Clay Co., The Engineer Co., Ruggles Klingemann Mfg. Co., Brown Instrument Co., and Coen Co.

Regulators

• First cost of a complete metering system of combustion control may, in some small plants, be considered by the engineer to be greater than is justified. Still the plant may be large enough to warrant some automatic control. For this a number of regulators are available that can be arranged to control fuel feed, air flow and furnace draft. Whether regulators are provided to control one or all of these factors depends upon the amount of money available, and the type of plant.

A hand-fired boiler, for example, may have only a damper regulator, whereas a stokered installation may have regulators controlling air supply and furnace draft, leaving control of fuel feed to the operator. The regulator controlling air flow is usually arranged to respond to changes in steam pressure. Often this same regulator also controls fuel feed through cams or other means so that change of fuel feed is about proportional to change in air flow. These controls, however, do not adjust for air-fuel ratio as do the more complicated metering control systems. Furnace draft is usually controlled by a separate regulator that operates the boiler outlet damper. In connecting dampers to regulators the counterweight should be arranged so it will tend to open the damper in case the regulator or connecting linkage should fail.

Regulators responding to variations in steam pressure are of two types: those operating full-stroke or off-and-on, and position regulators which graduate their operation so that the damper or other element under control assumes an intermediate position having a fixed relation to some point in the pressure range for which the regulator is set.

Off-and-On Regulators

The simplest form of on-and-off regulator is a Bourdon tube, bellows, or diaphragm arranged to make or break the control circuit of small motor-driven stokers having integral fans. This type of regulator is used largely on small heating installations and will not be discussed here.

Mechanical off-and-on regulators are often used to open and close the dampers of small boilers. Fig. 3 shows a Julian d'Este Co. single-acting steam-operated full-stroke regulator used in this service. This regulator in normal position has its piston B at the top of the cylinder, and the damper is held open by weight W. Valve V is held closed by an adjustable spring. When steam pressure acting on the valve and diaphragm D increases above the set spring pressure, the valve is opened,

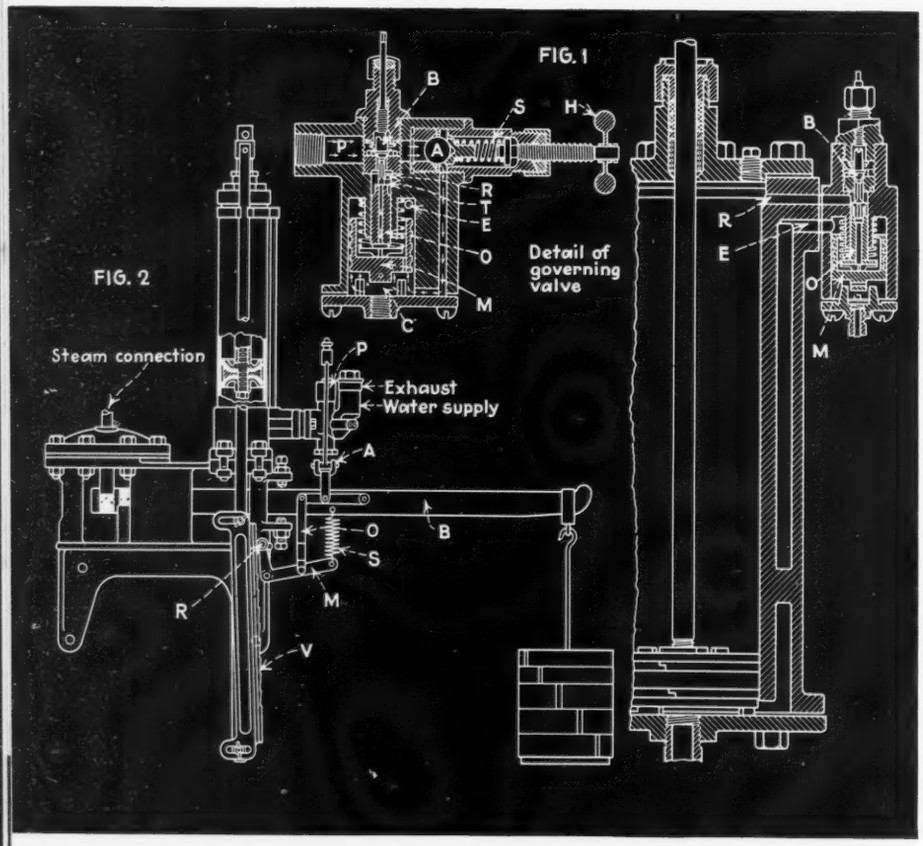


Fig. 1—Single-acting regulator with steam-operated power cylinder (Brown Instrument Co.). Fig. 2—Step-action regulator (Ruggles-Klingemann Co.)

admitting steam to the cylinder. This forces the piston down and closes the damper. Action of the valve is reversed with a pressure drop, and steam trapped in the space above the piston leaks off through an orifice in plug *O*, thus dampening the return of the piston as the damper is opened by the counterweight.

Position Regulators

Steam-pressure regulators applied to larger boilers are usually of the position type. They are ordinarily adjusted so that full regulation takes place over a range of 4 to 8 lb. for moderate boiler pressure. For example, minimum boiler rating will be carried at 200-lb. steam pressure, an intermediate rating at 196 lb. and maximum rating at 192 lb. For each pressure within this range, the regulator assumes a definite position. To accomplish this, various compensating or return mechanisms are employed, as will be explained as the various types of regulators shown in Figs. 1 to 10 are described.

Position regulators may be either single- or double-acting, depending upon whether power is applied to only one or both strokes. Likewise they may be operated by steam or by a secondary fluid such as water, oil, or compressed air. Fig. 1 shows the A-Jacks single-acting steam-operated steam pressure regulator made by the Brown Instrument Co. Dry steam at boiler pressure enters the chamber of pilot valve *P* and is resisted by check valve *A* held to its seat by spring *S*. Adjustment of *S* to desired boiler pressure is done with handwheel *H*. When boiler pressure exceeds this value, *A* is unseated and steam builds up in chamber *C* until it reaches 4 or 5 lb., sufficient to raise plungers *M* and *O* and lift check valve *B*, which is held against its seat by a spring. This allows steam to enter the top of the power cylinder through passage *R* and force the piston down, reducing air flow and fuel feed. The top of the piston rod engages a curved compensating rod fastened to the adjusting handwheel. As the piston moves down, it causes the handwheel to turn to increase tension in spring *S*, decreasing the flow of steam and pressure in chamber *C*, allowing piston *M* and plunger *O* to fall, closing valve *B* and locking the piston in position. If steam pressure drops, valve *A* closes and pressure in *C* decreases still further, allowing piston *M* to fall, uncovering port *T* through which steam in the cylinder exhausts, and a counterweight pulls the piston up. Exhaust steam passes through the stem of plunger *O* and into the jacket around the power cylinder.

Single-Acting Regulators

Another single-acting regulator, made by Foster Engineering Co., Fig. 7, employs a secondary fluid, usually water, to operate the piston. Steam pressure acting on diaphragm *D* and knife-edge *K* moves weighted beam *B* pivoted on fulcrum *F*. When pressure increases above the setting, beam *B* is lifted, moving pilot valve *P* through levers *A* and *C*. This movement connects the top of the cylinder to the drain, and the piston moves upward under influence of a counterweight. Tension is decreased in compensating spring *S* by means of a lever pivoted at *M*. This causes the beam to drop, returning the pilot valve to neutral and stopping piston movement. A pressure decrease causes the pilot valve to admit water to the top of the cylinder, forcing the piston downward and increasing fuel feed, air flow or damper opening, depending upon application.

Operating on the same principle but arranged differently, the single-acting Morey & Jones regulator, Fig. 6, moves the piston downward with an increase in steam pressure. Pressure from the boiler is led to point *A*, and water from a constant-pressure source is admitted at port *B*. Tension of the coil spring is adjusted to just balance the desired boiler pressure acting on the diaphragm. As pressure increases above this setting, the spring is compressed slightly. This allows steam to push the compensating arm down. This motion is transmitted to the pilot valve, a detail of which is shown above the regulator. The valve controlling the flow through port *B* is opened slightly, allowing water to flow to the chamber above the piston and there build up pressure to move the piston and control arm.

As the control arm moves, it increases tension on the compensating spring, which tends to close valve *B* and prevent further movement of the arm. If boiler pressure continues to increase, the action is repeated.

On a decrease in pressure, valve *B* will be closed and *C* opened slightly, relieving pressure above the

piston. As the central arm moves under the influence of a counterweight, a similar compensating action tends to close port *C*, holding the regulator in position.

The Arca regulator, Fig. 4, is also single-acting, but operates on the throttle principle. Water pressure is admitted to the chamber above diaphragm *D* and flows through passage *H* and out at *L*. Boiler pressure is admitted through pipe *Q* to act on sylphon *B*. Spring *O* acting through relay arm *A* balances the upward force of the steam and the force of the water at *L*. With a drop in steam pressure, sylphon *B* allows relay arm *A* to move down, throttling the water jet at *L* and increasing pressure on diaphragm *D*. This causes the right-hand end of lever *W* to move down and the left-hand end to move up, increasing tension in spring *S*. Movement of lever *W* continues until tension in the spring balances pressure on diaphragm *D*, when the regulator is in equilibrium. To one end of *W* is attached the speed-controlling device for the forced-draft fan, and to the other is attached the stoker or fuel-feed control.

An increase in pressure raises arm *A*, decreasing the throttling effect on the jet at *L*. This allows the water to flow more freely, decreases pressure above *D*, and *W* moves in a direction to slow up the forced-draft fan and fuel feed.

Double-Acting Regulators

By making the regulator double-acting, more positive action is claimed. The weight-compensated hydraulic regulator of Atlas Valve Co., Fig. 5, is of this type. Steam pressure is imposed on the under side of diaphragm *D* and is balanced by weighted beam *B*. In the position shown, steam pressure is low, valve *A* is closed, and full water pressure is imposed on the top of the cylinder through pipe *P*. Port *E* is open, allowing water on the under side of the piston to drain. Thus the piston is forced to the bottom of its stroke. As pressure rises, the beam is lifted, first closing port *E* and then lifting valve *A*. Equal water pressure is then imposed on both sides of the piston, but because the area on the top side is less than the area on the bottom (by the area of the piston rod) the piston is forced upward. Movement of the piston carries with it the rack which rotates gear *G*, causing weight *W* to move outward. This increased weight causes beam *B* to descend, closing valve *A* but not opening port *E*, so locking the piston in position. A drop in steam pressure causes the beam to fall, opening port *E* and allowing water to drain as the piston falls. At the same time *W* moves back, tending to hold the piston in position.

A double-acting regulator compensated with a movable fulcrum linkage is shown in Fig. 8. In this regulator, made by Davis Regulator Co., steam pressure acting on top of a diaphragm is balanced by weighted lever-arm *W* and spring *S*. An increase in pressure raises arm *W* and also arm *A*, which rotates about movable pivot *B*, lifting pilot valve *P*. This admits water under pressure above the piston, forcing it downward. The piston rod is connected to the forced-draft-fan and fuel-feed speed control to decrease air and fuel. Movable pivot *B* is on the end of a bell crank pivoted at *E*. Compensator rod *C*, the other end of the bell crank, slides through connecting arm *M* fastened to the piston rod. As the piston moves downward, angularity of *C* is changed, moving pivot *B* down, rotating arm *A* about *F*, and restoring pilot valve *P* to neutral, so locking the piston in place.

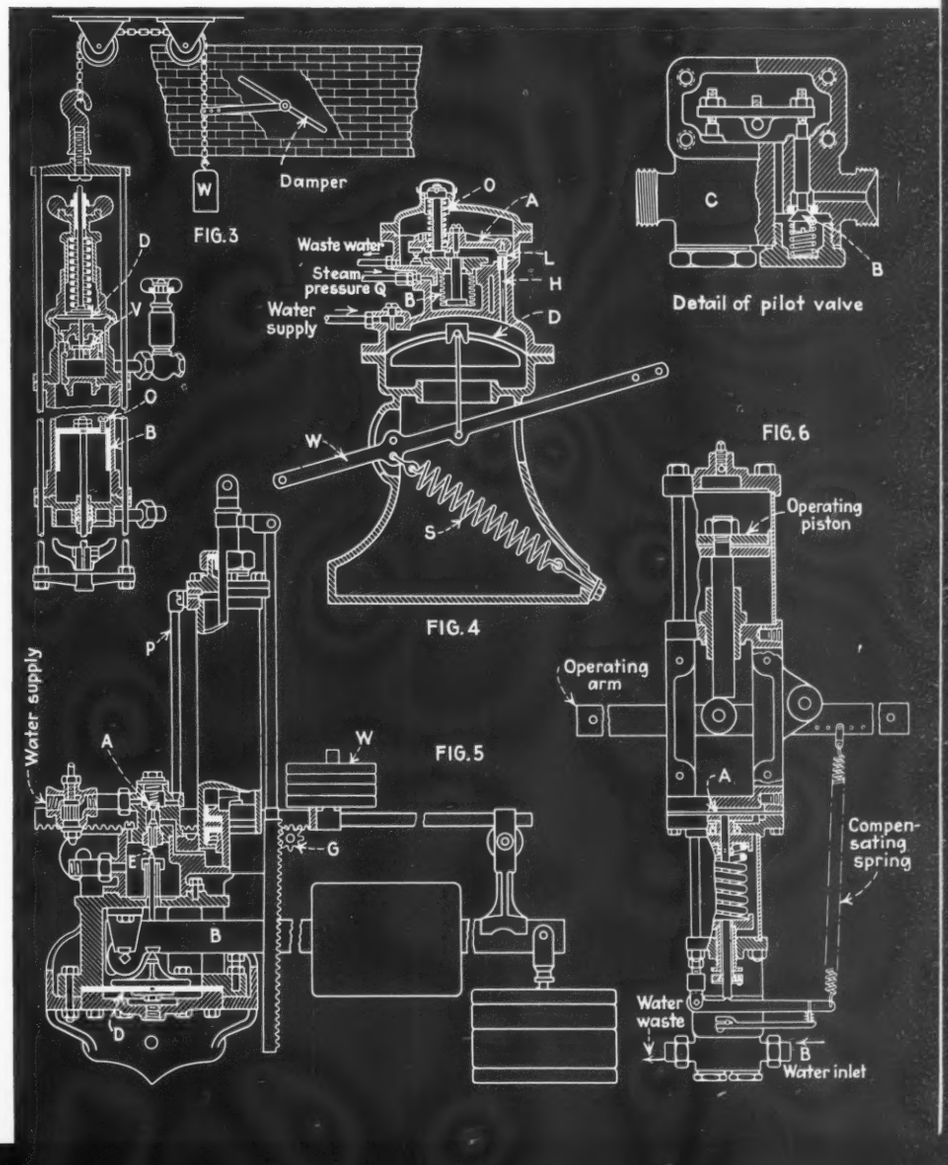
A decrease in pressure allows arm *W* to drop, moving pilot *P* down to relieve pressure above the piston and admit pressure under it, forcing it upward. A wide range of control can be had by changing the length of arm *M*.

Step-Action Regulator

In the Ruggles-Klingemann double-acting hydraulic regulator, Fig. 2, a step action is secured that makes this regulator particularly adaptable for connection to motor speed controllers, as the step positions of the regulator can be made to correspond to the steps in the motor controller.

In the Ruggles-Klingemann double-acting hydraulic regulator, Fig. 2, an increase in pressure lifts beam *B*, yoke *A* and pilot valve *P*, admitting water pressure under the piston and opening the top of the cylinder to the drain. As the piston moves upward, it carries with it step wedge *V*. Due

Fig. 3—Single-acting full-stroke regulator (Julian d' Este Co.). Fig. 4—Pilot valve of a single-acting regulator operating on the throttle principle (Arca Regulators, Inc.). Fig. 5—Weight-compensated double-acting regulator (Atlas Valve Co.). Fig. 6—Double-acting regulator with spring compensator (Morey & Jones Co.)



to design of the wedge, there is very little movement of the compensator levers until roller *R* contacts the first notch. The outward movement of *R* is transmitted through bell crank *M* and arm *O* to bring *P* back to neutral. It also increases tension on spring *S*, thus increasing slightly the pressure setting of the regulator. Further increase in pressure above this setting causes the regulator to move another step. When steam pressure decreases, the operation is reversed. By adjusting the angularity of *V*, any desired pressure range per step can be secured.

The regulator shown, Fig. 2, has equal steps. When applied to damper operation to control furnace draft, adjustable steps are provided so that instead of equal movement, the piston moves in small steps at first and in larger steps at the end of its travel. This moves the damper in small increments when it is nearly closed and in large steps when nearly open, giving equal increments in gas flow for each regulator step.

Furnace-Pressure Regulators

Furnace-pressure regulators or draft regulation is little different from steam-pressure regulation. The furnace-pressure regulator must be much more sensitive because its actuating force is usually measured in hundredths of an inch of water. By using a large diaphragm, some of the regulators previously described have been successfully applied in this service.

In the combination draft controller and recorder, Fig. 10, made by Bristol Co., furnace pressure acts on inverted bell *B* which rotates shafts *A* and *C* and vane *V*. Air is admitted at 15-lb. pressure at *M*. Part of the air flows downward to pilot valve *P* and part goes through constriction *N* to sylphon *R* and nozzles *J*. Jets of air from these nozzles are throttled by *V*, the extent of the throttling depending upon the position of *V*. When *V* cuts the jets entirely, throttling is at a maximum and pressure is built up on *R*, operating the pilot valve which floats between upper and lower seats.

When the pilot valve passes more air than can leak off to atmosphere through *D*, pressure builds up in the line to the controlled mechanism, which may be a diaphragm-operated valve or air-operated piston and cylinder. The shaft *C* carries a recording pen arm.

Another Type

Fig. 9 shows another air-operated furnace-draft regulator. It is made by Mason Regulator Co. and is supplied with air at 15-lb. pressure from a reducing valve. Air pressure is transmitted to fixed orifice *A*. The seat on actuating arm *B* is partially closing orifice *C*, therefore pressure from *A* builds up in chamber *D*. Increasing pressure in *D* forces valve *E* closed and valve *F* open, allowing line pressure to enter chamber *G* flow through the bypass and equalize pressure in *H*. As soon as pressure in *G* balances the upward force in *D*, valve *F* closes, holding pressure constant in *G*. This air pressure is applied to the damper-control diaphragm.

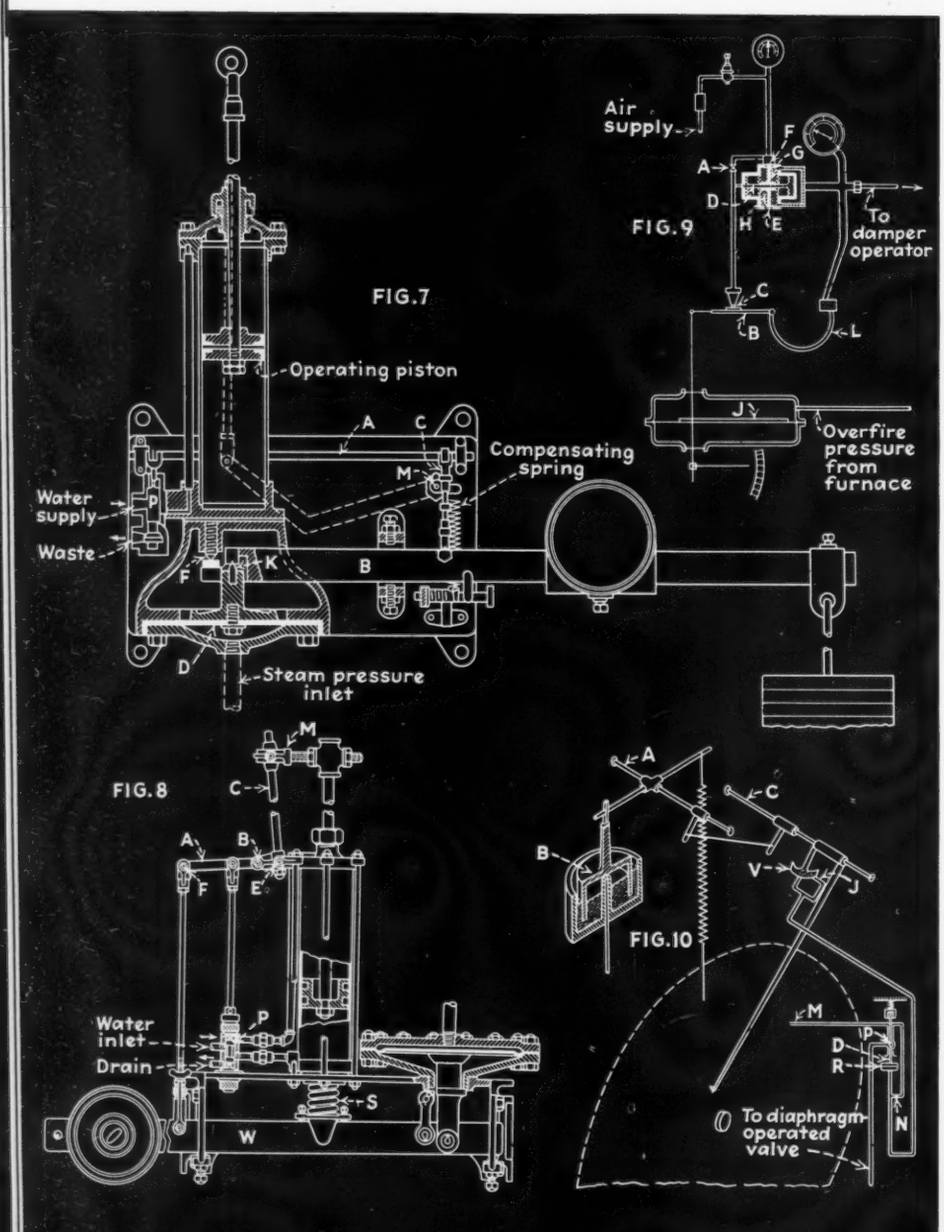
The over-fire pressure which is being controlled acts on diaphragm *J*, an increase in pressure forcing it downward. Downward movement of *J* causes arm *B* to rotate partially opening orifice *C* reducing the pressure in *D*. This opens valve *E* permitting the pressure in *G* and *H* to balance *D* again, reducing the pressure above the damper diaphragm and allowing it to open.

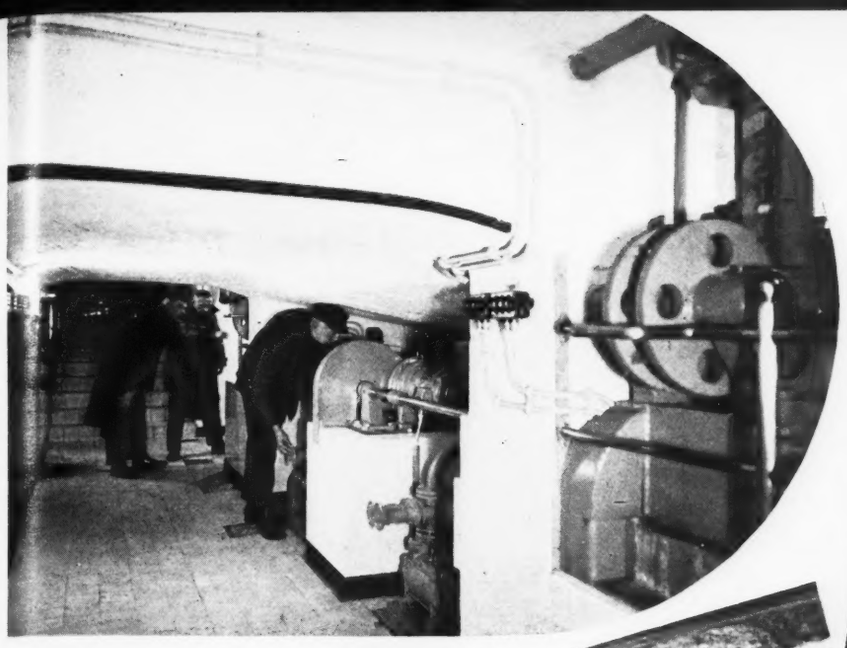
This regulator has a compensating device to prevent over-controlling. Control pressure in *G* and *H* is also exerted in Bourdon tube *L*. An increase in this pressure lowers the pivot about which *B* rotates, moving *B* away from the orifice, which tends to reduce operating pressure slightly and so prevent overcontrol.

Other Makes

Among other manufacturers of regulators whose equipment has not been illustrated or described, due to lack of space, are Atwood & Morrill Co., Engineer Co., Spence Engineering Co., Watts Regulator Co., Weeks Merit Co., and Coen Co.

Fig. 7—Single-acting regulator with spring compensator (Foster Engineering Co.). Fig. 8—Double-acting regulator with linkage-return mechanism for compensation (Daves Regulator Co.). Fig. 9—Furnace-draft regulator air-operated (Mason Regulator Co.). Fig. 10—Combination furnace draft regulator and recorder (Bristol Co.).





Submarine Power

Said to be the world's first underwater power station, this submerged hydro plant at Rostin, Pomerania, Germany, went into operation Jan. 17. Its two small turbines are attended by one man and cost is claimed to be much less than that of the conventional station

The plant itself (top photograph) is built beneath the dam (center), so must be entered through a manhole (upper right) at one end. It extends from shore to shore, supplies all neighboring villages with cheap power, and controls floods which formerly caused much damage to the rich adjacent farming country each spring and fall. Installation cost was only 220,000 Marks, including redirecting the Persante River. At right, No. 2 machine is being put on the line. Photographs from Pictures Incorporated

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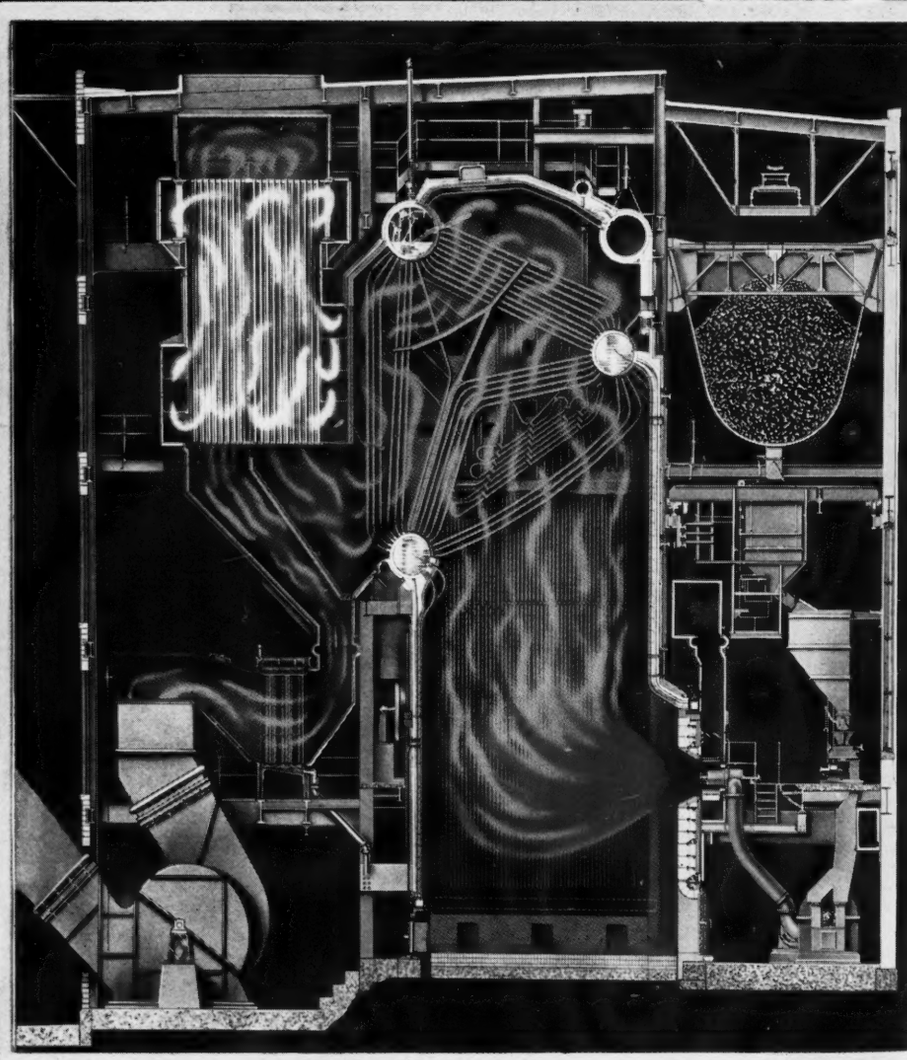
Westvaco also manufactures a variety of by-products such as activated carbon, chalk, liquid chlorine, caustic, turpentine, alcohol and fatty acids.



RILEY STEAM GENERATING UNIT

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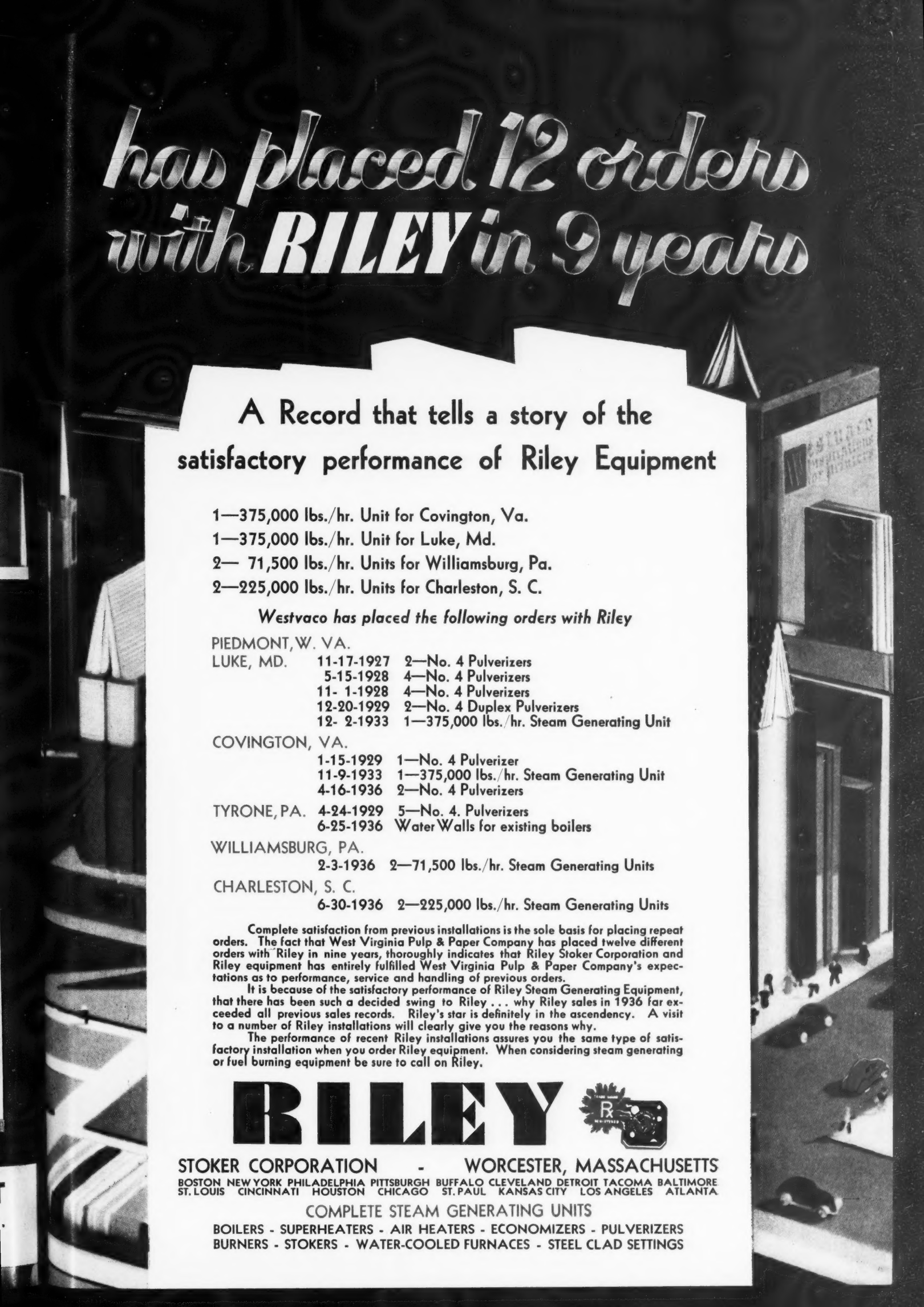
1—375,000 lbs.—600 lbs. Press. 750° F. Steam



has placed 12 orders with **RILEY** *in 9 years*

A Record that tells a story of the satisfactory performance of Riley Equipment

1—375,000 lbs./hr. Unit for Covington, Va.
1—375,000 lbs./hr. Unit for Luke, Md.
2— 71,500 lbs./hr. Units for Williamsburg, Pa.
2—225,000 lbs./hr. Units for Charleston, S. C.

Westvaco has placed the following orders with Riley

PIEDMONT, W. VA.		
LUKE, MD.	11-17-1927	2—No. 4 Pulverizers
	5-15-1928	4—No. 4 Pulverizers
	11- 1-1928	4—No. 4 Pulverizers
	12-20-1929	2—No. 4 Duplex Pulverizers
	12- 2-1933	1—375,000 lbs./hr. Steam Generating Unit
COVINGTON, VA.		
	1-15-1929	1—No. 4 Pulverizer
	11-9-1933	1—375,000 lbs./hr. Steam Generating Unit
	4-16-1936	2—No. 4 Pulverizers
TYRONE, PA.	4-24-1929	5—No. 4. Pulverizers
	6-25-1936	Water Walls for existing boilers
WILLIAMSBURG, PA.		
	2-3-1936	2—71,500 lbs./hr. Steam Generating Units
CHARLESTON, S. C.		
	6-30-1936	2—225,000 lbs./hr. Steam Generating Units

Complete satisfaction from previous installations is the sole basis for placing repeat orders. The fact that West Virginia Pulp & Paper Company has placed twelve different orders with Riley in nine years, thoroughly indicates that Riley Stoker Corporation and Riley equipment has entirely fulfilled West Virginia Pulp & Paper Company's expectations as to performance, service and handling of previous orders.

It is because of the satisfactory performance of Riley Steam Generating Equipment, that there has been such a decided swing to Riley . . . why Riley sales in 1936 far exceeded all previous sales records. Riley's star is definitely in the ascendency. A visit to a number of Riley installations will clearly give you the reasons why.

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BOILERS - SUPERHEATERS - AIR HEATERS - ECONOMIZERS - PULVERIZERS
BURNERS - STOKERS - WATER-COOLED FURNACES - STEEL CLAD SETTINGS

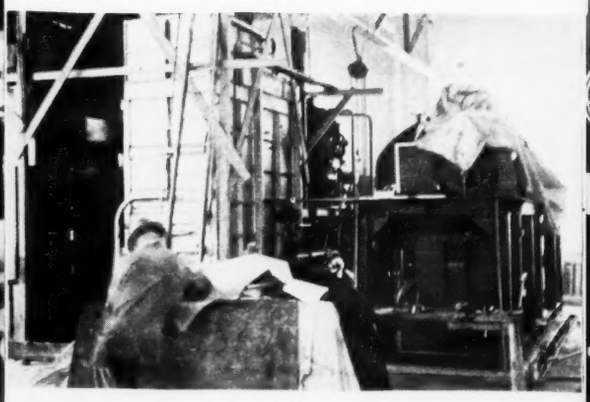
Ford

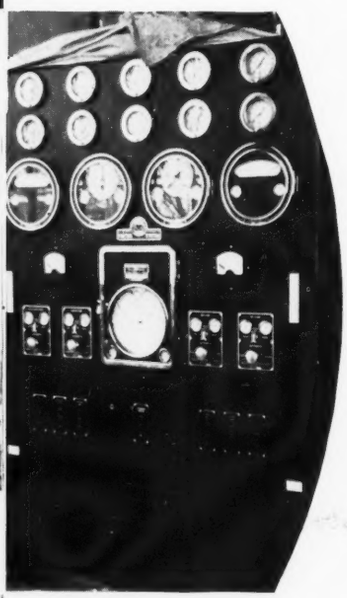
At this corner of the new building is a glassed-off, tiled-floor section for the new unit and an auxiliary heating boiler, whose stack can be seen. The water-wheel provides standby power

This reciprocating-engine plant is soon to be replaced by the new installation

Right—The 750-kw. turbine is mounted high over its condenser. This view is from the manufacturing plant through the glass partition

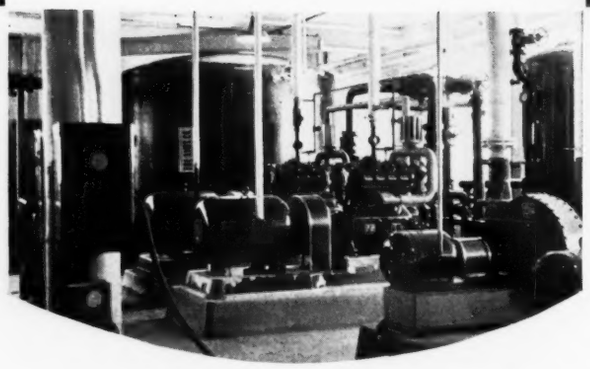
Instrument-panel gages. Top line—lube-oil pres. on main turbine, boiler feed, cond. storage level, propane press., burner-oil pres., 2nd line — lube-oil pres. of aux. set., cond-pump pres., H.P. extraction, fuel-oil pres. at pump inlet, burner-air pres.; 3rd line — separator-drum level, extrac.-steam pres., steam pres., air and oil flow; 4th line—turbine-speed indicators; 5th line—spill-over valve, water flow, recorder-controller, air-flow, oil flow; 6th line—blank, lube-oil pump, condenser pump, auto-ignition, vac. pump, aux. pump, blank





Above is the heating boiler at the moment when the first fire was started (Feb. 15)

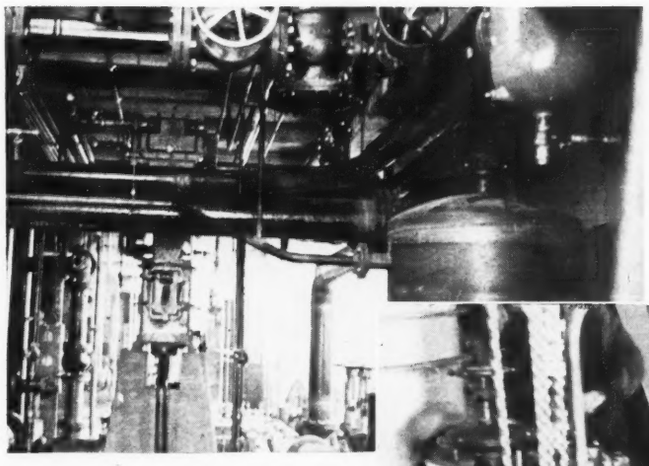
Photo at right shows the model air-compressor room downstairs



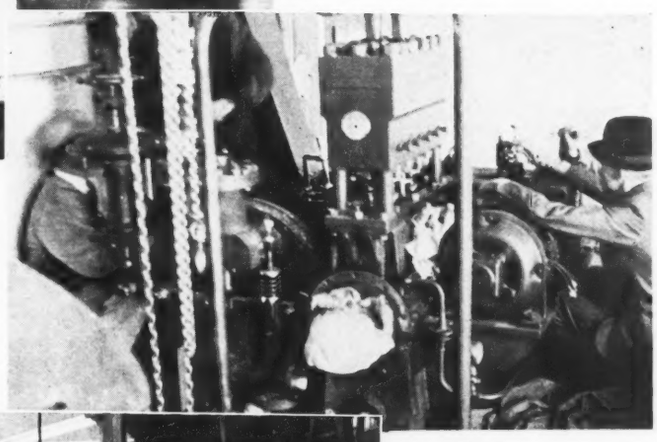
In the center photo, at left is the heating boiler, next the 1,200-lb., 900-deg., 10,000-lb. per hr. vertical oil-fired boiler with auxiliaries high up behind it, and at right the turbine, with condenser beneath it and evaporator between boiler and turbine

Installs a Steamotive

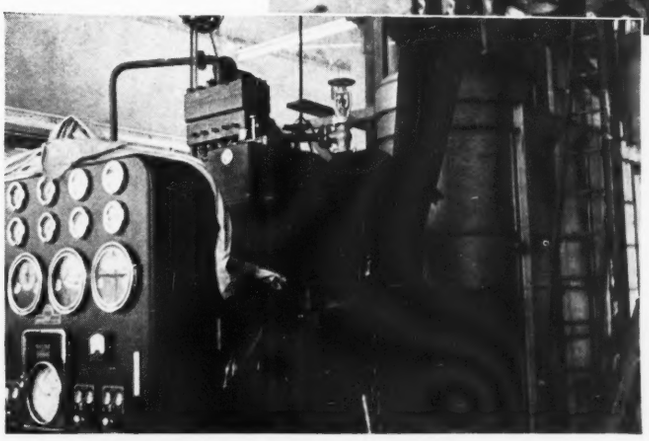
At Northville, Mich., a small Ford plant makes 70,000 valves a day. The first complete stationary Steamotive unit is now being installed there, to provide 750 kw., plus process steam at two pressures



Above—Piping under the Steamotive, showing auxiliary-boiler deaerating heater in background, all-welded piping, and boiler blow-off tank at right

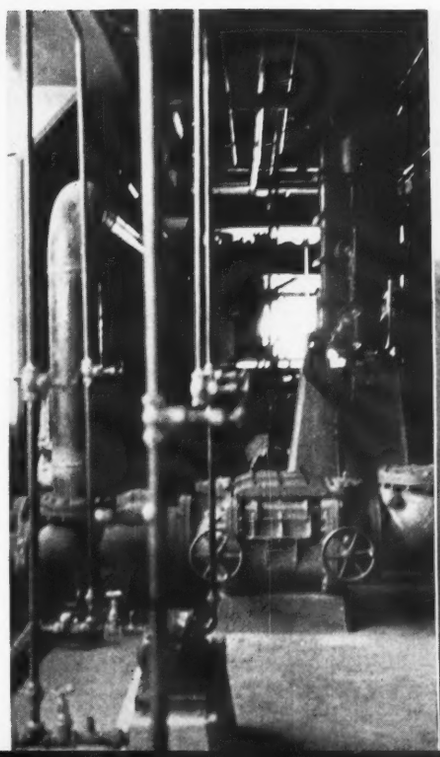


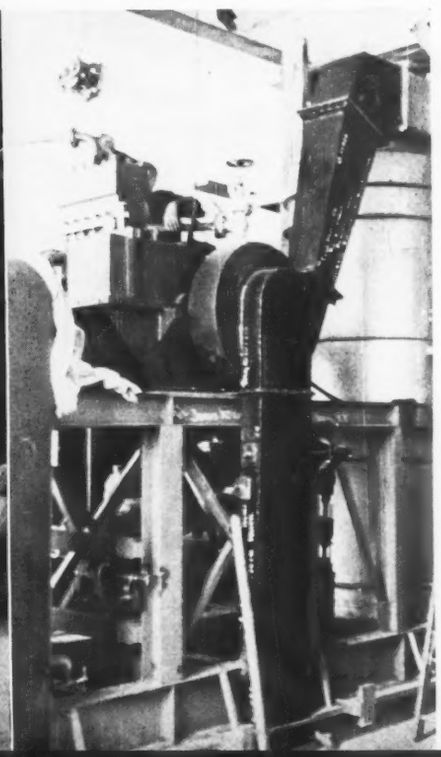
Auxiliaries, all driven by one turbine, include lubricating-oil pump, fuel-oil pump, feed pump and forced-draft fan. The whole plant weighs 22,800 lb., of which the turbine is 4,200, steam generator 12,000, gear 2,000, exciter 1,000, base 2,100, and air cooler 1,500



View from side of Steamotive boiler auxiliaries, showing forced-draft fan and boiler-feed pump

Arrangement of board, auxiliaries and vertical boiler. Fired with bunker C, the boiler has automatic propane-air ignition. Steam bled at 5 lb. and 150 lb. goes to building heating, the evaporator and to process, including heating soda water and the grease extractor for cleaning plant products





Mill water strainer and auxiliary boiler feedwater heater

Cross-sectional drawings and data on the Steamotive were in POWER for Mid-December, 1936. Power's candid-camera photographs taken Feb. 15

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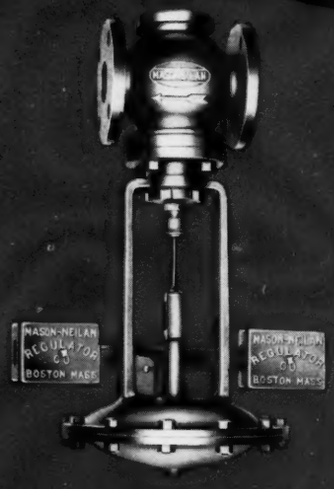
Whatever Your Pressure Reg regulator in the Masoneilan

THIS complete line—a few items of which are illustrated here—includes equipment for steam, water, air, gas and oil reducing and back pressure service; for pump pressure regulation; for industrial and domestic heating and water systems; for primary and secondary lines, large or small. Each is a combination of correct design, highest quality materials and precision workmanship; each is tested under actual operating conditions; each is so built

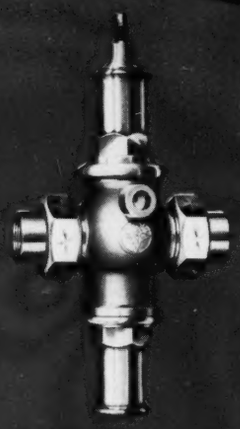
No. 27—EXTERNAL PILOT OPERATED

For accurate control under widely fluctuating demands, in primary high pressure lines. Bulletins 27, 47.



No. 236 A-S—DIRECT OPERATED

For heating and other low pressure steam systems. Catalog 63.



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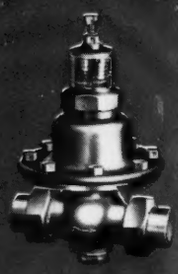
For precise control in secondary steam lines where accuracy is the prime factor. Catalog 63.



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This half century of diligent research in field and laboratory have brought about developments resulting in refinements and improvements which set new standards for accurate, dependable, enduring service. Write for bulletins and complete information.

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MASONEILAN

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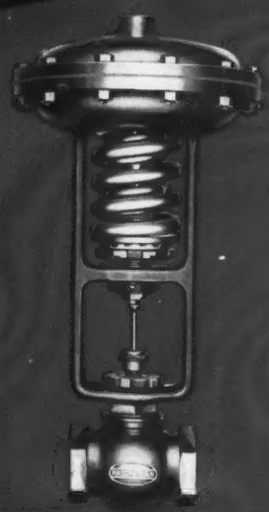
For large or small air lines. Accurate control with full pipe capacity. Catalog 63.



No. 585-S—DIRECT OPERATED

For close regulation where steam or water demand is steady and tight shut-off is not necessary. Also for pump pressure regulation. Catalog 63.

No. 29—EXTERNAL PILOT OPERATED

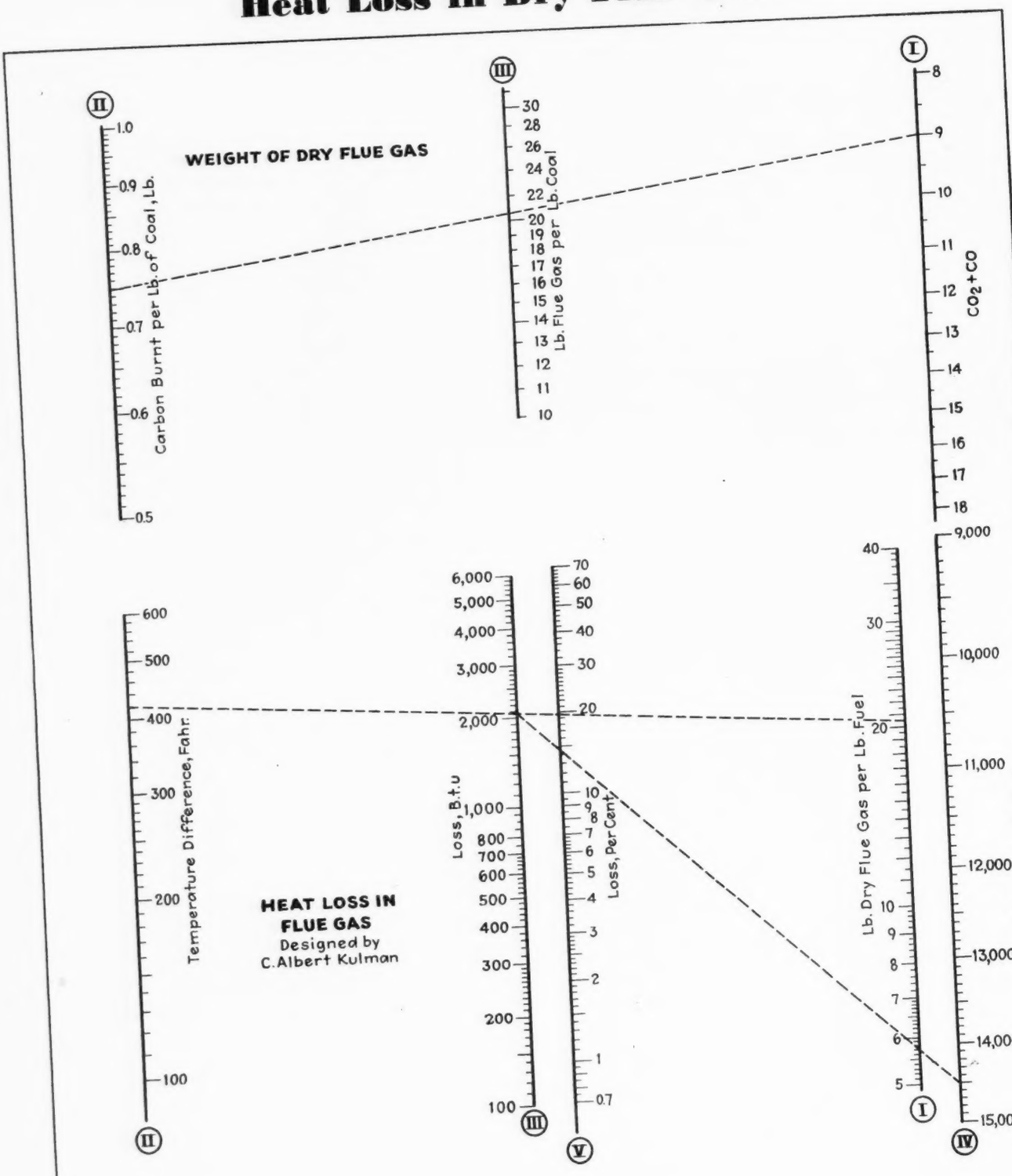
For accurate reduction of gas pressures, particularly fuel gas to engines, boilers, etc. Bulletin 29-F.

OIL PRESSURE REGULATORS

1186 ADAMS STREET, BOSTON, MASS.

Tulsa St. Louis Houston Los Angeles

Heat Loss in Dry Flue Gas



THIS is the first of a series of charts for determining boiler efficiency and heat losses from boilers. To find the heat loss in the dry flue gas, first find the weight of dry flue gas per pound of coal from the top chart and then use the bottom chart to find heat loss.

Example—8.8% CO_2, 0.2% CO, 0.75 lb. carbon burnt per lb. of coal. Temperature difference between flue gas and room 420 deg. Heating value of coal 14,500 B.t.u. Sum of CO_2 and CO is 9%. Connect this value on Scale I of top chart with 0.75 on Scale II and read 20.5 lb. of gas per lb. of coal on Scale III. Enter lower chart with this value on Scale I and connect it with 420 deg. on Scale II. At intersection on Scale III, read heat loss in B.t.u. Connect this point with heating value of coal on Scale IV and read per cent loss of 14.4% on Scale V.

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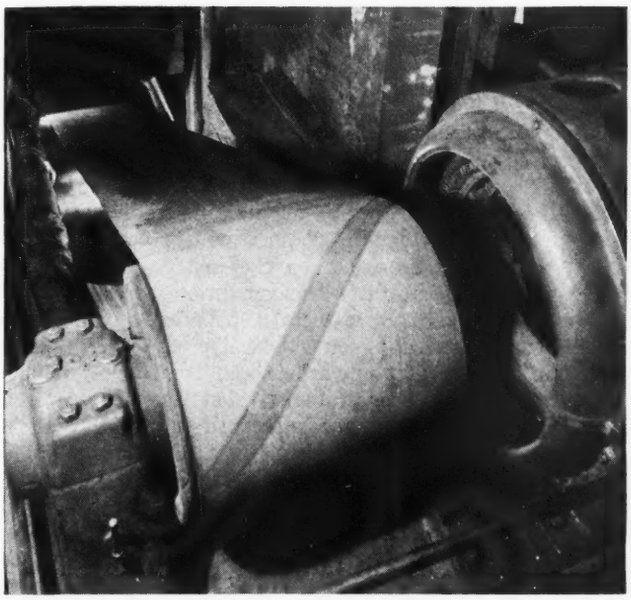
PRACTICAL AIDS TO OPERATION



Five-Year-Old Belt Remodeled for New Drive Requirements

TO OBTAIN EFFICIENCY, we often consign to the junk pile old equipment which might, with a few minor changes, be adapted readily to other operations within a plant. However, Franklin Board and Paper Co., Franklin, O., overlooked no such opportunities when it made alterations in motive-power equipment.

This company, in 1931, installed a 101 ft., 40-in., 10-ply rubber belt on a Corliss-engine drive. In the spring of 1936, after the belt had seen almost 5 years continuous service, the drive was abandoned. Considering the length of such service and that the company had no other drive requiring a belt of this size, it would have been easy for the management to justify its disposal from a cost angle. Examination, however, showed it to be still in excellent condition and capable of many more years of operation.

The belt was returned to our plant, where it was cut to 60-ft. length and 32-in. width, stripped down from 10- to 9-ply and then made endless by a Plylock splice. Then, the remodeled belt was installed on the 250-hp. drive, shown in the photo, where it has now been in operation for almost a year.

Conversion of the belt resulted in little or no loss of material. The remaining 40 ft. of belt, as well as the strip left from the original cutting down operation, were cut into 6- and 8-in. widths and stripped to 4-ply for various transmission purposes about the plant.

Akron, Ohio — R. W. SMITH, *B. F. Goodrich Co.*

Some Suggestions on Waterwalls

A NUMBER of factors contribute to failure of boiler tubes under internal pressure and exposure to direct radiant heat. Localization of heat produced by flame impingement on tubes, as occurs with fuels burned in suspension, tends to cause evaporation and water flow faster than water can be supplied. This may result in steam pockets, overheating, bulging and in some cases, tube rupture.

Excessive slag formation is another result of flame impingement. Cooling of flame below ignition temperature before combustion is completed has another detrimental effect. This causes low CO_2, an appreciable amount of CO, and a general loss in combustion efficiency.

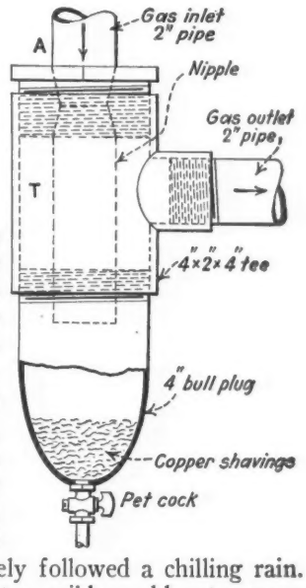
Use of correct size burner and burner adjustment are important steps in flame control. Forcing a burner will often cause an improperly proportioned flame. Conversely, too large a burner for the load carried will cause low combustion efficiency and possible trouble with burners. Adjusting primary air to fuel-feed rate and draft is also an important factor in control of flame proportion.

Severe injury to lower slag-screen tubes may be caused by heavy pieces of slag falling from the upper slag screen, or water-wall tubes. Often slag formation builds up to weights of over 100 lb., which may fall 40 ft. onto a row of tubes under pressure. One of the best ways to avoid this trouble is to prevent flame impingement, and further, by using coal that will not slag at reasonable furnace temperatures.

General feedwater treatment to prevent scale or corrosive action is no different with waterwall boilers than with a boiler without screen tubes. Waterwalls are actually part of the boiler proper. However, as these tubes are exposed to high temperature and operate with high evaporation rates per unit of heating surface, exacting feedwater treatment is necessary to preclude all possible scale formation. Scale-forming matter in solution should be precipitated out as sludge by proper treatment. This should be done as far as possible before water enters the boiler or waterwalls, and sludge removed before it has accumulated to any extent.

Chicago, Ill. — CHARLES A. ARMSTRONG

Homemade Trap Solves Gas-Engine Trouble



VERTICAL 4-cyl. gas engines on steady load as prime movers for a crude-oil pipeline station began to show intermittent periods of irregular running. After several suspected causes of irregular firing were checked, and when the trouble was about to be laid to the age of engines, it was noticed that each recurrence of the knock coincided with or closely followed a chilling rain.

This led to the theory that possibly sudden temperature change caused a portion of the gaseous fuel to be

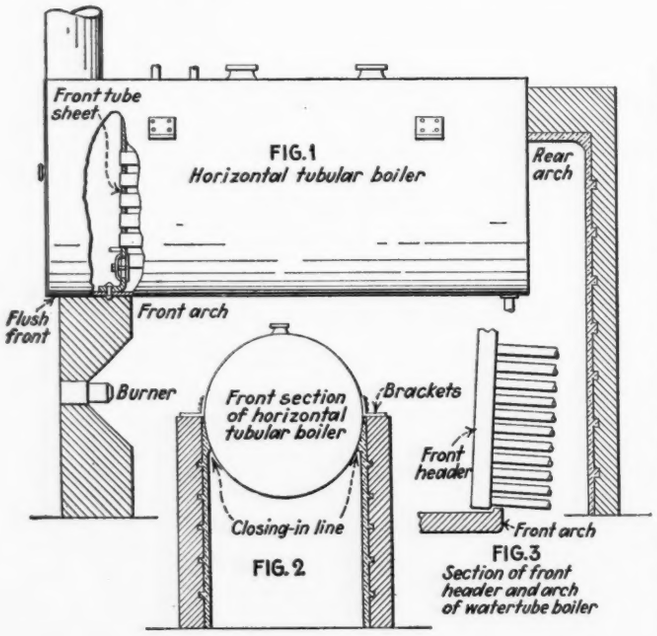
condensed to the high-test gasoline. To check this, the intake line feeding No. 1 engine was enclosed for 6 ft. of its length in a wooden trough, in which a charge of crushed ice and salt was placed. Almost before the freezing mixture touched the pipe the trouble recurred, and our theory was confirmed. When the ice-salt mixture was replaced with warm water, regular operation returned.

With a 4x2x4-in. cast-iron tee as a base, a home-made expansion chamber and trap was fabricated for each engine, as in the illustration. Gas enters through *A*, expands in chamber *T*, and any liquid being carried by it is deposited in the base of the plug by sudden change in flow direction. To prevent this liquid from being picked up by the gas stream and carried into the engine, a pad of copper shavings—a pan scourer bought from the nearest 5- and 10-cent store—was placed in the plug base.

This copper mesh also trapped a surprising quantity of tarry matter, the deposit having a decidedly gritty feeling. At each shut-down period the bull plug was removed, the pad taken out and washed in gasoline, dried and replaced.

A marked change in internal conditions of the engine was noticed, which we consider a result of trapping this gritty substance. A large portion of this material is infinitesimal rust flakes from within the pipeline. Where formerly carbon in ring grooves was almost as hard as the piston itself, now it is of a more flaky composition, and can be cut with almost the smoothness of a well made carbon brush. Since station engines have been equipped with intake traps, no further recurrences of the trouble have been experienced.

Longview, Texas — ELTON STERRETT



Danger Points in Furnace Masonry

A TENDENCY of modern boiler design is to use less brickwork and more water-heating surface. However, there are still many types of boilers that need considerable amounts of masonry. Fig. 1 shows an elevation of a horizontal-tubular boiler of the flush-front type. The front tube sheet is flanged outward to form the circumferential seam, and the shell plate projects about 15 in. to form the smoke-box. Rivets in this front seam are not cooled by water, as with the h.-t. boiler having the front tube sheet flanged inward.

While many boilers of this construction are set so that the smoke box projects beyond the forward wall (over-hanging front type), the flush-front boiler depends on the front arch to prevent overheating. If this arch breaks down, the riveted seam and dry sheet (smoke-box bottom) will be exposed to direct heat. Overheating of the dry sheet, burned rivet heads, and seam failure may result.

The rear arch protects the rear-tube sheet above the water line. Failure of this arch would allow high-temperature gas to come in contact with rivets and tube sheet not cooled by water on the inside. Overheating and failure may result if this condition persists.

Fig. 2 is a front view of an h.-t. boiler, supported by riveted brackets resting on side walls. Furnace linings, of firebrick, are built upwards about 6 in. below hanger lugs, and below longitudinal-riveted seams. At this point, furnace linings are offset slightly towards the boiler shell, hugging it to form the closing-in line. The closing-in line protects hanger lugs or brackets, longitudinal-riveted seams, and shell plates above the water line from direct action of hot gas and overheating. Dislodging of brick from the closing-in line has caused serious accidents from burned-off brackets and overheated riveted seams.

The front arch in water-tube boilers, Fig. 3, gives protection to the bottom of front headers. A natural pocket for sludge and sediment is formed in the construction of either box-header or sectional-sinuous type. Arch failure allows direct heat to come in contact with the header bottom. Continued overheating may result in failure at this point.

Cleveland, O. — A. G. WIGGINS

Explosion of Enclosed Motor

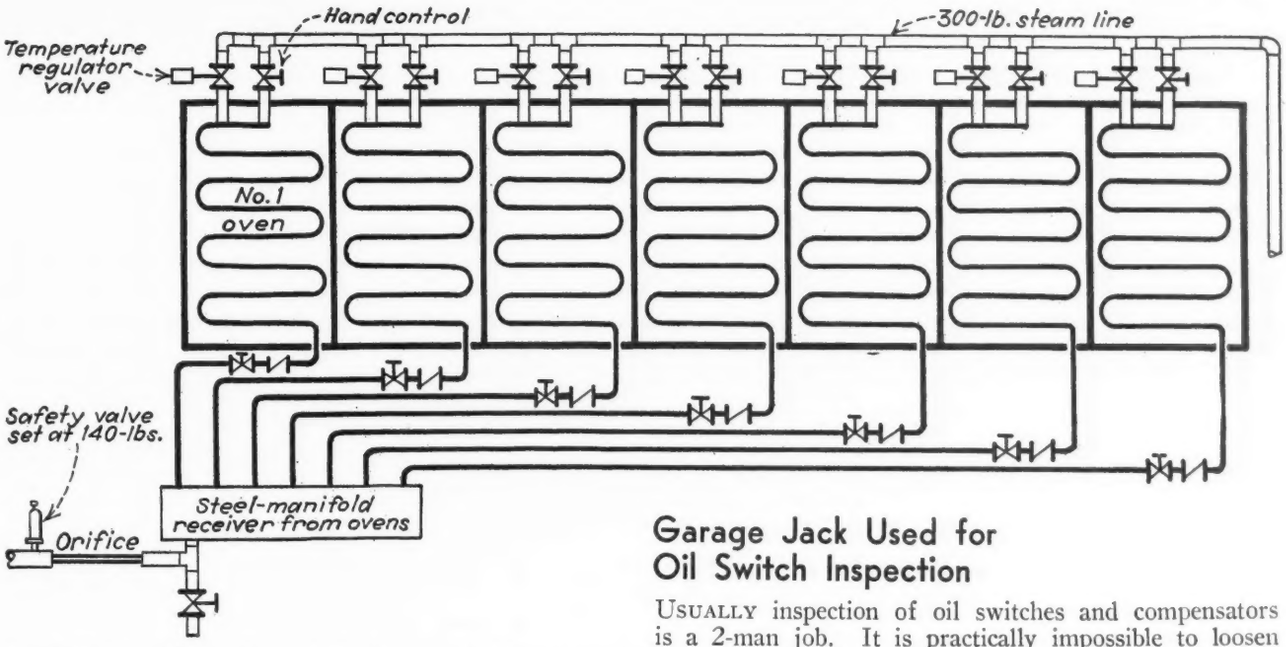
EXPLOSION of an electric motor may appear to be a very remote possibility, but in at least one case it did occur with an enclosed type while on test. Investigation revealed that during manufacture, the insulating compound had been mixed with a voltatile thinner which had not been driven out of the varnish during drying. After the motor had been put on test and operated at full load for a time, temperature increase caused the varnish to give off sufficient volatile to form an explosive mixture in the motor. The mixture was probably ignited by brush sparking.

Worthing, England — W. E. WARNER

Orifice Drain on Ovens Cuts Steam Cost

IN OUR manufacturing processes we have 7 lacquer-drying ovens heated by 300-lb. steam, each controlled by two valves, one hand-operated and the other regulated by oven temperature, as shown in the figure. Originally, ovens and steam line were drained by 9 high-pressure traps to the feedwater heater in the boiler room. It was difficult to keep these traps in good working condition and, as a result, considerable steam was lost through them.

To eliminate these difficulties, we decided to operate ovens as reducing valves between the 300- and 125-lb.



steam lines. We made a steel-pipe manifold and connected the outlet of each oven into it. An orifice, made from a piece of stainless steel 0.75 in. in diameter, 6 in. long with a $\frac{3}{16}$-in. axial hole through it, connected the manifold to the 125-lb. line, as in the figure above.

After all traps were removed and the new system put into service, we found that we do not need to drain the high pressure line as ovens are never completely shut off and oven drains to the receiver manifold are always open through the orifice. We have several traps on the 125-lb. line, but at this pressure and no superheat they are easily kept tight. Whenever the plant is not operating, both the 300-lb. and the 125-lb. lines are shut off. The system has been in operation for over two years and an average saving of $132.00 per month has been made based on steam flow-meter readings. Part of this may be accounted for by condensate returns from ovens not being required for feedwater heating, as there is an excess of exhaust steam for this purpose from other sources.

Rochester, N. Y. W. J. GESSNER
Chief Engineer
Taylor Instrument Companies

Pulley Diameter Used for Speed-Ratio Calculations

USUALLY it is assumed that thickness of the belt should be added to the diameter of the pulleys when calculating speed ratio between two pulleys connected by a flat belt. For example, if the driving pulley is 6-in. in diameter, the driven pulley 18 in., and the belt 0.25 in. thick, the speed ratio is 18.25 to 6.25, or 2.92 to 1. This is true for two-ply leather belts and for rubber belts that have their neutral plane in their center. For single-ply leather belts, run with their grain side on the pulleys, the neutral plane is about 67% of the thickness of the belt away from the pulley. For such belts, add 1.35 times the thickness of the belt to the diameter of the pulleys when figuring the speed ratio of the pulleys. If the belt is operated with the flesh side on the pulley, its neutral plane is inside its center and only 0.65 times belt thickness is added to the pulley diameter.

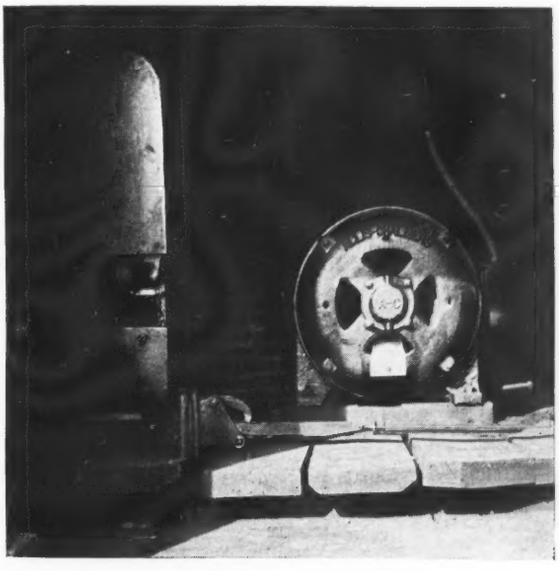
Garage Jack Used for Oil Switch Inspection

USUALLY inspection of oil switches and compensators is a 2-man job. It is practically impossible to loosen both sides and lower the oil tank without help, except for smallest switches. Where a great many oil-filled switches are to be serviced, it may pay to have a special lifting device, but not where the number is limited.

To make it possible for one man to service these switches and compensators, an ordinary high-lift automobile jack is used in one plant. The jack is standard equipment in many garages and may be obtained with a down position height of about 4 in., and an extended height of 22 in., making a possible raise of 18 in. In the plant where this idea is being used, the jack serves a good part of its time in the company garage and the electrician borrows it when necessary.

The photograph shows the oil pan being lowered on a 2,300-volt oil compensator used for starting a motor. The jack weighs about 40 lb. and can be easily inserted into tight quarters. The lifting handle need only be worked up and down a short distance. Of approximately 20 oil tanks, only two of them are in such a position that the jack cannot be used. By some slight rearrangement of apparatus, these switches might also be serviced and this work is contemplated in the near future.

Sayreville, N. J. K. B. HUMPHREY



CURRENT COMMENT

Freon Compressor Capacity

IN HIS answer to the question, "What Capacity Freon Compressor," Jan. *Power*, page 40, A. G. Solomon makes a serious error when he "corrects" theoretical Freon flow rate of 218.5 lb. per hr. per ton and obtains 263.2 lb. per hr. per ton as the required rate of circulation. No correction is necessary, and 218.5 lb. is the weight actually required.

The expansion valve is a throttling device. Saturated liquid at 85 deg. enters the valve. There pressure drops and the liquid is cooled by partial evaporation ("flashing") so that a mixture of saturated liquid and saturated vapor at 37 deg. leaves the valve. In any throttling action, heat content after throttling is the same as heat content before throttling. In this case, then, heat content of the liquid-vapor mixture at 37 deg. equals the heat content of the liquid at 85 deg., or 27.48 B.t.u. per lb. This is the heat content of the liquid-vapor mixture as it enters the evaporator.

If the Freon leaves the evaporator as saturated vapor at 37 deg., as Mr. Solomon assumes, it then has a heat content of 82.38 B.t.u. per lb. Since evaporation takes place at practically constant pressure, the heat absorbed by each pound of Freon in the evaporator equals the increase of its heat content between inlet and outlet, or 82.38 — 27.48 = 54.90 B.t.u. The required rate of circulation is 12,000 divided by 54.9, or 218.5 lb. per hr. per ton. This is the actual rate as well as the theoretical.

The error in Mr. Solomon's reasoning arises from his assumption that some energy is lost in the expansion valve, and that this energy is the amount involved in the cooling of liquid by flashing in the expansion valve. The only loss of energy that could occur at the valve would be a loss of heat to the atmosphere; but, as liquid enters the valve at practically room temperature, and as it leaves the valve at a much lower temperature, there must be a gain rather than a loss of heat at this point. Neglecting this gain, which in any case would be small, we see that heat content before and after the valve must be the same.

An alternate way of figuring refrigeration per lb. of Freon, which further demonstrates the error, is as follows: Mr. Solomon finds that 16.89% of the liquid flashes in the valve. This is correct, and it is, in fact, the quality of the liquid-vapor mixture that enters the evaporator. That is, for each pound of liquid that enters the valve, there emerges 0.1689 lb. of saturated vapor at 37 deg. and 0.8311 lb. of saturated liquid at 37 deg. Heat content of the vapor is 82.38 × 0.1689 = 13.90 B.t.u.; the heat content of the liquid is 16.32 × 0.8311 = 13.58 B.t.u. And 13.90 + 13.58 = 27.48 B.t.u., which checks with the heat content of one pound of liquid at 85 deg.

The 0.1689 lb. of flash, being already vaporized, passes through the evaporator unchanged and thus produces no refrigeration. But the 0.8311 lb. of liquid absorbs its full latent heat at 37 deg., so that the actual refrigerating effect is 0.8311(82.38 — 16.32) = 54.90 B.t.u., which checks with the refrigeration per lb. of Freon found by the first method.

The actual flow rate required, then, is 83% of the rate determined by Mr. Solomon, and corresponding reductions in all of his subsequent figures that depend on the rate should be made.

PROF. LAWRENCE WASHINGTON
Stanford University, Cal.

High-Speed Engines

OUR ATTENTION has been called to your editorial comment in August, (1936), *Power* on the subject of high-speed steam engines, and to the reply of N. A. Campbell in the January, (1937), number.

Several years ago we built and tested an 8-cyl. V-type uniflow steam engine for high-speed service. Economy obtained was practically the same as that of our counter-flow single-cyl. engines of equal horsepower. The difficulty was in keeping condensation from cylinders out of lubricating oil.

Unfortunately, in an engine of this type, reliability does not measure up to that of the old moderate-speed steam engine which users have been accustomed to operate in their plants for 30 or 40 years, and there is no question that the higher-speed engine will require more maintenance and attention. The only thing to be gained is speed, and, as you say, this would decrease generator cost, if direct-connected.

The main difficulty is water in the oil and, so far, we do not know how this difficulty can be overcome.

Troy, Pa. F. J. VONACHEN
Troy Engine & Machine Co.

What's Wrong—XII

IN CONNECTION with the drawing of a "Heating System" in February *Power*, the following additional items should be incorporated in the list of errors:

1. The pump is not provided with a vacuum gage.
2. The pump is not provided with a vacuum regulator.
3. There is no vent shown in the sketch.
4. There is no vacuum relief valve on the pump.
5. There should be a gate or stop valve on both sides of the reducing valve, so that it can be repaired.
6. The steam piping is not properly proportioned. Low pressure lines should be larger than the high pressure lines.
7. What would happen to the system if the reducing valve on the line should fail and there was no safety valve on the line to protect the system?
8. There is no automatic cutout to operate float mechanism in the pump.
9. There is no separator on the pump.
10. The valves should be placed as close to the radiators as possible, by unions.

Buffalo, N. Y. JOHN J. TIMMONS.

Flood Waters Call for Strong Precautions

I AM sketching, very briefly, some of the effects of the recent flood, and primarily, some of the precautionary measures that might be taken.

In a flood of this nature, where water rises over a considerable area of lowlands, rate of rise is seldom too rapid to prevent taking certain precautions. In our case, we anticipated an unusually high flood, although by no means as high as we actually experienced. At no time did the water rise more than 2 in. an hr., which gave us ample time to remove motors and certain raw materials that did not involve too much of labor and time.

About 2 days after water passed flood level, our electric power supply failed us, which, in turn, hindered greatly the work of removing equipment to a still higher level when we found that the flood was going beyond the stage we had anticipated. As a consequence, motors which could not be moved were jacked up as high as possible and in some cases not high enough to prevent damage. Of course, conduits, power lines and switches were all hopelessly bogged. Our steam lines, in many cases, will have to be re-insulated, and lagging in stills renewed.

In the stress of preparing for high water, it was faintly amusing to find that we had neglected to open valves in bottoms of empty tanks, and since our water supply was also out, we had to form a bucket crew to fill them in order to keep them from floating off their foundations.

Our most anxious moments came when the second floor of the building over our shop was flooded by acetylene generated from a drum storage of calcium carbide for a welding outfit; and when we watched, helpless, as waters almost floated from its foundation an 8,000-gal. tank of sulphuric acid, which we naturally could not flood.

It appears to me that a few precautions might be listed:

Pick a level which you anticipate the flood will not reach, and move equipment at least 5 ft. higher, while power is still on.

Secure bungs in all oil drums, drain all transformer oil, and remove any possible source of oil leakage.

If drums of lube and cleaning oil, or naptha, can not be securely housed or moved to higher ground, anchor them in batches to a firm support with sufficient lead to allow for floating, and, if possible, on the lee side of a structure.

Open bottoms of all empty tanks, and fill completely any partially-full tanks.

Remove drums, and remove or open tanks beneath power and steam lines and shafting. We had one rather serious difficulty caused by a tank catching steam and power lines and breaking them before it could be released. Considerable damage resulted to shafting sprung from floating tubs.

Louisville, Ky. GEORGE WHITESIDES
Manager Bituminous Dept.,
Kentucky Color & Chemical Co.

READERS' PROBLEMS

QUESTIONS for Our Readers

Coal Sticking in Silo

Question 1

DURING *wet weather, coal hangs up in our 80-ft. high concrete coal silo, and must be barred down by hand. Does anyone know of some way to prevent coal from sticking to the side walls?*—S.S.D.

How Much Diesel Capacity?

Question 2

OUR *industrial diesel plant contains three slow-speed 300-kw. diesel sets. Demand is normally about 500 kw., but may rise to 700, and overnight and on weekends drops to about 75. It has been suggested that a 100-kw. high-speed diesel set would be able to handle peaks (with two present engines running), and could handle the weekend load alone. Considering the fact that we already have 900 kw. of capacity in three units and that the difference between combustion efficiency at half and full load on a diesel is relatively small, I don't feel that the additional unit is justified. Again, if we replace one 300-kw. unit with the 100-kw. set, load growth within the next year or two may give us insufficient capacity, and there is ever-present the necessity for running all three units at full load in order to meet a 700-kw. demand. Have* POWER *readers anything to suggest from their experience with multi-engine plants? What are the factors to be considered and the general principles to be followed?*—R.E.T.

Suitable answers from readers will be paid for if space is available for publication.

GENERATOR FIELD

ANSWERS to February Question 1

The Question

WE ARE *shortly going to start up a new 5,000-kw. turbine and the question has come up as to when the generator field should be taken off when this unit is shut down. Should the same practice be followed with a machine of this size as with a unit of 50,000 kw? What are the influencing factors?*—C.M.J.

Wait Until Unit Stops Before Opening Field

YES, the same method of field operation for your 50,000-kw. unit is also applicable to your new 5,000-kw. unit. If your generators are equipped with direct-connected exciters, it is good practice not to remove the field until the generator has come to rest. If your generators are separately excited, remove the field just before the generator stops. If the generator field circuit is opened while the generator is rotating at or near its normal r.p.m., an instantaneous high potential will be set up in the field winding from the collapsing d.c. field, which will tend to puncture field-circuit insulation.

This high potential, however, is usually discharged into a non-inductive resistance that is automatically cut into the field circuit by an auxiliary switch attached to the field switch. When the field switch is opened, the auxiliary switch is closed and vice versa. This non-inductive, field-discharge resistance is primarily used to protect the field winding should the generator be automatically removed from service by a differential or other relay which also opens the field switch as well as the "H" breaker.

Amsterdam, N. Y. F. MURRAY ACKER

Field Off After Opening Main Breaker

OPERATORS at the University of Washington plant are called upon to handle both the switching and the turbine. Switching is done in one trip to the board, and then operators are able to give their complete attention to the turbine and auxiliary equipment. Turbine load is shifted to the other units at the switchboard. During unloading, the exciter and voltage regulator are kept within their proper range by correct adjustment of field and exciter rheostats. The main breaker is opened when load is nearly zero. The voltage regulator is switched out when the proper resistance adjustments are obtained on the field and exciter rheostats. When field resistance is all in, the field breaker is opened. Switching is completed by transfer of proper meter plugs. The unit is then allowed to coast to a stop.

No difficulties are experienced with this procedure. Factors governing field switching are: convenience and the fact that operation may be neglected and attended to later. The field breaker may be opened at any time after the main breaker is opened, providing that field resistance is all in. The field, however, may be left on as the machine is slowing down to act as a magnetic brake on the generator rotor, and thus assist the spindle in slowing down more rapidly.

This may be an important factor in shutting down the 5,000-kw. unit, and a still more important factor with the 50,000-kw. unit, due to a variety of difficulties arising from too long coasting. Time saved, will of course, be greater with larger machines, and may in itself be the determining factor. The same principles apply to both machines.

Seattle, Wash. FLOYD D. ROBBINS
University of Washington

Remove Field From Condensing Units

WHEN shutting down turbo-generators, the field is usually left on until just before or just after the rotor has come to rest. There are, however, conditions when it is not advisable to follow this practice.

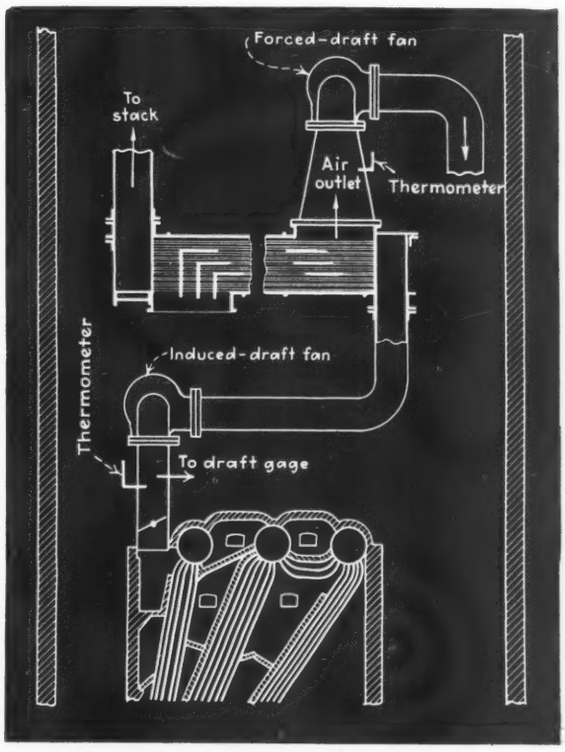
For example, in the case of a moderate size condensing unit not provided with a vacuum breaker, if the field is left on when the unit is stopped, the rotor will slow down and probably stop before the vacuum is broken. As soon as the shaft seal is broken, cold air will leak in and cause uneven cooling that may result in shaft distortion. By opening the field circuit as soon as the throttle is closed, the unit will roll for a longer period, thus giving an opportunity for the vacuum to break before the unit comes to rest. Of course, the auxiliary oil pump must be kept in operation while the machine is coasting to rest.

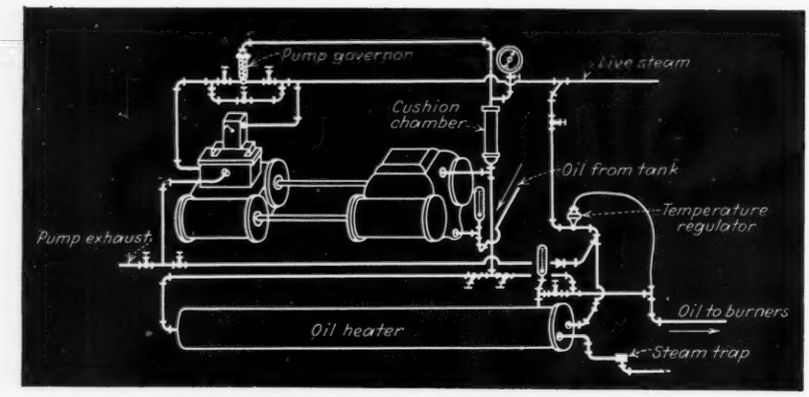
Detroit, Mich. P. R. BROCKNER

WHAT'S WRONG WITH THIS PICTURE?—XIV

Air Preheater and Fans

THERE are at least eight departures from good practice shown in this drawing. Make a list of those you recognize, then check against the list on page 230.





Control of Oil-Burner Pulsations

WE HAVE *four reverberatory furnaces heated with oil supplied by a reciprocating pump. At the nearest furnace to the pump, which is quite close, serious pulsations are experienced in the oil flow. These pulsations are very objectionable in the graphic meters, because the graph is so wide as to seriously affect the accuracy in controlling the oil. We try to maintain the oil pressure at about 25 lb. per sq.in. and the air at 20 to 30 in. of water at the burners. What can we do to improve operation?* —M.R.

Installation of a cushion chamber such as described by me in December, 1936, *Power*, page 635, will help even out pulsations. In all probability, the size recommended in the article will be ample but from experience I would say that, although a chamber of too small capacity may give trouble, it is almost impossible to have one which is too big. If in doubt, I would err on the side of too large capacity.

I would also suggest that piping be arranged so that there are no high spots near the burners, or anywhere on the discharge side of the pump. In high spots, such as vertical loops, gas bubbles are likely to accumulate and eventually be shot through the burners, causing puffing. This is, of course, more probable if high-viscosity oil is being used, which requires high-temperature for atomization.

The purpose of a pump governor on a reciprocating steam pump is to control steam pressure on the piston by throttling, so that the oil piston will be able to supply at all times the required amount of oil to the burners at the required pressure. To put it in more mathematical form, pressure on the steam piston is maintained as a predetermined function of oil pressure. This is done by automatically controlling the steam throttle by means of a pressure pipe, generally transmitting oil pressure from the discharge line to a diaphragm which operates the steam valve.

Oil pressure is sometimes taken from the top of the cushion chamber. The diagram shows the method employed by one manufacturer. I would recommend putting a governor on the steam pump. I assume from what you say that you are atomizing with compressed air. It is of course advisable that the air pressure should be steady.

It is not at all easy to get a meter which will accurately register hot-oil flow, because of variation in viscosity, etc. When you have made the recommended changes, I would suggest that you test the meter accuracy by measuring oil taken from the tank during a period of time, and checking this with meter records.

Bloomfield, N. J. JAMES O. G. GIBBONS

ALGAE FORMATIONS

ANSWERS to February Question Number 2

The Question

ALGAE *formations in our 100,000-c.f.m. air-conditioning units are causing us a great deal of trouble. It is necessary to shut down quite frequently to remove these accumulations. Cooling and de-humidifying is done with cold spring water and no mechanical refrigeration is used. Can someone tell me how to control these growths?*—A.J.C.

Treat With Chlorine And Alum

ALGAE growths can be prevented by accurately introducing a trace of chlorine in the cold spring water used in the cooling and humidifying system. This treatment is generally about 75% effective. For 100% effective results, chlorine-treated spring water should also be treated accurately with a trace of commercial alum and then be filtered through a conventional pressure-sand filter.

Clayton, N. J. S. F. ALLING

Copper Sulphate Will Destroy Algae

DESTRUCTION of algae growth in water may be accomplished by dosage with copper sulphate. Concentration required depends on a number of factors among which are: kind of algae, hardness of water, amount of organic matter present, temperature, and the presence or absence of dissolved CO_2. It is apparent, therefore, that the proper dosage must be determined for the specific water being used as the cooling medium.

However, some idea of the requirements may be given. Kellerman, of the U. S. Department of Agriculture, determined the copper sulphate concentration necessary to destroy 36 varieties of algae among which were Asterionella, Spirogyra, Anabaena, Oscillaria, Uroglena, Baggiatoa, and Crenothrix, which are more or less common varieties. Among those named, he found that the greatest dosage required, that for Baggiatoa, was 41.5 lb. per million gal. of water at 60 deg. F., this figure to be increased by 1¼% for each degree drop in temperature below 60 deg. Thus, if it be assumed that the cooling water has a temperature of 40 F., the quantity of copper sulphate required would be about 52 lb. per million gal.

In adding copper sulphate to the water in question, it may be assumed, initially, that a maximum of 50 lb. per million gal. will be required, which is assuming that the algae present is Baggiatoa, one of the most difficult to destroy. By experiment, it may be found that a considerably smaller

WHAT'S WRONG WITH THIS PICTURE?—XIV

Air Preheater and Fans—See Page 229

DEPARTURES from good practice shown in this picture are restricted to location of equipment and provisions made for maintenance and efficient operation.

1. Induced-Draft Fan Improperly Placed. Induced-draft fan should be installed after the air preheater, in which location it will handle gas at lower temperature. This reduces its size and the horsepower required.

2. Uneven Gas Distribution. With this arrangement of ducts, more gas will tend flow through the tubes, it should be heater. This leads to corrosion in the bottom tubes.

3. Air Preheater Improperly Placed. If a tubular air preheater is designed for gas flow through the tubes, it should be vertically placed. If tubes must be horizontal, gas flow should be outside. In the arrangement shown, moisture condensing from the flue gas will remain in the tube and cause corrosion.

4. No Hopper for Soot Removal. A soot hopper should be provided at exit end of the air preheater, in which soot thrown out of the gas may collect. A hopper at the 90-deg. turn after the induced-draft fan would also be advisable.

5. No Room Provided for Replacing Tubes. Space should be provided at one end of the preheater so that corroded tubes may be removed and new ones installed.

6. Forced-Draft Fan Improperly Placed. The forced-draft fan should be placed on the inlet side of the preheater. As installed, the fan receives heated air, increasing size of fan required and the power required to drive it.

7. No Thermometer at Flue-Gas Exit from Preheater. An indicating or preferably a recording thermometer should be installed in the flue at the preheater exit. This, together with thermometers at the boiler exit and hot-air duct, make it possible to check preheater performance.

8. No Draft Gage at Flue-Gas Exit from Preheater. A draft gage should be installed in the flue at the preheater exit to check draft loss and hence cleanliness of the preheater.

dosage is required. For example, Anabaena requires a dosage of only 0.8 lb. per million gal. and Uroglena only 0.4 lb., determinations having been made at 60 deg. Of course, the type of algae may be determined by submitting a sample to a bacteriologist before the treatment is started.

In adding copper sulphate to reservoirs, it is customary to add the solid material. The method of making the addition in the present case will depend on the conditions of operation. Periodical teratments will be required, frequency of which will have to be determined by experiment.

Elizabeth, N. J. J. L. EVERHART

Copper Sulphate Most Economical

FRANK E. HALE, Director of Laboratories, Department of Water Supply, Gas and Electricity, City of New York. states in a treatise written for the Nichols Copper Co., "Microscopic organisms are the minute plant and animal life that are present in all surface water and some well water." Coupled with that statement and the writer's own experience, it seems phenomenal that algae should be found in an underground supply of water such as a cold spring.

A common method of control of various organic growths found in water is the copper sulphate treatment. It is preferable to other methods because of economy and ease in handling. Chlorine as a control is expensive because it calls for costly equipment, constant maintenance, and, in addition, must be used in conjunction with an ammoniator in order to keep the chlorine in solution. Chlorine alone is not very effective in handling a serious algae condition; at least, that has been my experience. A heavy residual of chlorine is necessary in order to control plant organisms effectively.

I suggest that A.J.C. obtain a copy of "The Use of Copper Sulphate in Controlling Microscopic Organisms," by Mr. Hale, and study the various classifications of plant life, characteristics and control. Several methods of application are described in the pamphlet, any one of which may solve A.J.C.'s problem.

Topeka, Kan. D. F. JOSLIN

Cutting off Light Controls Algae Growth

GROWTH of algae depends on various factors, such as temperature and light. Algae will not grow in darkened places. It is often impossible to cover the water supply, in which case the copper-sulphate treatment can be used. If spring water is held in some sort of a reservoir before entering the system, that is the point at which copper sulphate should be applied. Application may be done in any number of ways, such as placing a certain amount in a burlap bag and allowing it to dissolve in the water, continuous application with dry feed, or with solution-feed apparatus.

It should be remembered that best results are achieved when copper sulphate is thoroughly dissolved, mixed and given time to act upon the algae. The continuous application tratment is best as it keeps the system free at all times from algae growth. Doses vary from 1 lb. of copper sulphate per million gal. of water on up, depending on the species of algae.

Wingdale, N. Y. ROBERT V. GREVERT

THE ENGINEER'S BOOKSHELF

Thermodynamics

THERMODYNAMICS (1937). *By Stanton E. Winston, Associate Professor of Mechanical Engineering, Armour Institute of Technology. Published by American Technical Society, Drexel Ave. at 58th Street, Chicago, Ill. 178 pages. 5½x8¼ in. Price $1.50.*

This is a practical text covering the fundamentals of the thermodynamics basic to the engineering field. In order to make this book as clear as possible, the more complicated mathematical functions have been eliminated or avoided. Its sections cover fundamental principles, laws of ideal gases, thermodynamic processes for ideal gases, and heat-engine cycles. Comprehensive sets of problems and their answers are at the end of each chapter.

This book is a clear, understandable textbook of value to the fields of air conditioning, diesel engines, refrigeration, and steam power plants. Is well illustrated and thoroughly indexed.

Energy Control in Germany

STAAT UND ENERGIEWIRTSCHAFT (1936)—*By A. Friedrich. 160 pages, in German. Published by Franckh'sche Verlagshandlung, Lutzowplatz 1, Berlin, Germany. No price stated.*

Under the present regime in Germany, the entire energy industry is organized as a governmental agency to coordinate production and utilization of energy, under whatever ownership, as a national resource. The book first traces varying relationships between government and the power industry in the successive periods that may be termed the pre-war, war, collapse and inflation, and currency stabilization eras. This occupies about 60 pages and provides a historical background for what follows.

Instead of attempting to summarize various addresses of authoritative spokesmen and various decrees and regulations, the compiler has chosen the method of direct quotation. These quotations constitute the major portion of the book. For the American reader, this publication's chief interest will probably be found in the rigorous control indicated over corporate state, communal and municipal undertakings.

Chemical Engineering

ELEMENTS OF CHEMICAL ENGINEERING (1936)—*By W. L. Badger and W. C. McCabe. Second edition. Published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. 660 pages. 6½x9 in. Drawings, charts, diagrams, tables, and inserted humidity chart. Price $5.*

For *Power* readers this review should make clear the sharp distinction between chemistry and chemical engineering. Chemical formulas are relatively few, but many technical advances are included. In particular, important changes have been made in the chapters on heat flow, evaporation, drying, distillation, gas absorption, extraction and filtration.

The book deals with the design and operation of equipment for processing materials on a commercial scale. In a surprising number of cases, equipment and operation are similar to those encountered by the power engineer. He, like the chemical engineer, is concerned with flowmeters, pumps, valves, pressure vessels, heat insulation and exchangers, evaporators, and air conditioning. It is, therefore, a modest estimate to say that at least 50% of this book is of direct interest to power engineers. In addition, power engineers in the process industries are naturally interested in process application.

While the presentation is distinctly practical throughout, the authors do not avoid a little calculus and an occasional difficult computation, particularly when dealing with such subjects as heat transfer. The book will be particularly valuable to all designers of heat-transfer equipment, whether in the power field or elsewhere.

BRIEF REVIEWS

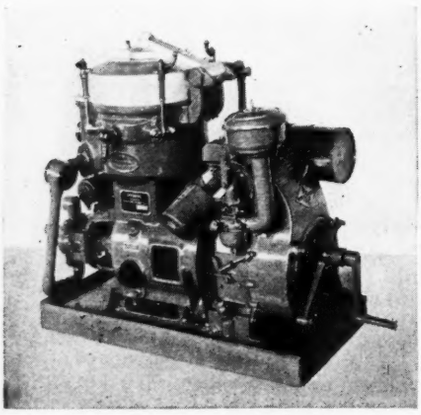
DIE DAMPFKESSEL. *By Ing. A. Loschge, Professor in the Munich (Germany) Technical School. Published* (1937) *by Verlag von Julius Springer, Berlin, W. 9, Linkstrasse 22-24, Germany. 424 pages, 6x9 in. Price 24 marks*—In translation, complete title would read, "The Steam Boiler—Text and Handbook for Technical Schools and the Higher Machine Construction Schools, as well as for Engineers and Technicians." Illustrated with 343 charts, diagrams, photographs and drawings. For the consulting engineer and boiler manufacturer.

LEFAX DATA. (1936). *From Lefax Inc., Philadelphia, Pa.*—Recent Lefax fillers include order No. 36-68, "Diesel Fuels", No. 36-70, "Table of Latent Heat of Vaporization", No. 36-74, "Effect of Pulsating Loads on Belts", No. 36-76, "Freon Refrigeration Equipment".

A.S.T.M. TENTATIVE STANDARDS (1936). *Published by A.S.T.M., 260 S. Broad St., Philadelphia, Pa. Cloth binding, $8.00; paper binding, $7.00*—Contains 264 tentative specifications, methods of test and definitions of terms of widely-used engineering materials.

WELDING AND CUTTING YEAR BOOK (1936-37). *Edited by C. Helsby, C. W. Hamann and F. J. Samuely. Published by Temsbank Publishing Co., Ltd., 12 Whitehall, London, S.W.1. Price 5 shillings*—A review of recent developments, equipment and welding methods. Several chapters on welding procedure on different materials, 260 pages, 5½x8¼ in.

WHAT'S NEW IN PLANT EQUIPMENT



OIL PURIFIER

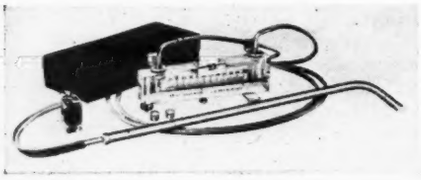
FOR PURIFYING fuel or lubricating oil where electric power is not available, gasoline-engine-driven centrifugal purifier has "300 Hydroil" unit mounted on drip bedplate with Briggs & Stratton 4-cycle engine. Capacity up to 450 gal. fuel oil and 300 gal. lube oil per hr.

Goulds Pumps, Inc., Seneca Falls, N. Y.

STEAM HOSE

"GREAT SEAL ASBESTOS CORD" hose a 4-ply asbestos cord wound spirally in alternating directions around a steam- and heat-resisting tube embedded in rubber. ½-, ¾-, 1-, 1¼- and 1½-in. I. D. sizes for 175 to 200 lb. pressure. Said not to char under high temperatures. Maximum length 50 ft.

New York Belting & Packing Co., 1 Market St., Passaic, N. J.



AIR METER

FOR READING static pressures, velocities, cu.ft. per min., drafts, etc., portable meter has gage, tubing, fittings, oil, data sheets in stiff carrying case, with pitot "static-head" tube. Transparent Bakelite gage said not to leak while being carried, easy to keep clean, and to avoid errors due to parallax. Various types cover velocities from 400 to 8,000 ft. per min., or vacuums as low as 0.005 to 4 in. of water. Bulletin F.

Julien P. Friez & Sons, Inc., Baltimore, Md.

BELT HOOKS

"WIREGRIP" hooks mounted on special cards, permitting workmen to cut off desired number without destroying others. Said to be made of finest wire available and to stand long, continuous, hard usage. May be applied with any standard belt lacer. Catalog No. 10.

Armstrong-Bray & Co., 308-310 N. Sheldon St., Chicago, Ill.

GATE VALVES

MADE OF carbon-molybdenum steel for 150 and 300 lb. steam pressure. Heavy wall thickness, deep stuffing boxes, over-size stems, streamline flow and steel handwheels with fluted non-slip rims.

Walworth Co., 60 E. 42nd St., New York, N. Y.

MERCURY SWITCHES

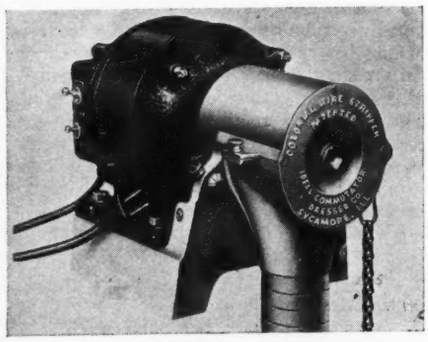
"STALEY" switches have mercury-to-mercury make-and-break contact housed in hydrogen-filled metallic envelope. Operated by tilting through angle of about 10 deg. from horizontal. Reversing switch in its clips provides reversal of circuit function (make instead of break). 5-, 10- or 15-amp. capacities. Said to have low contact resistance, reliability of operation, long life, and freedom from breakage.

Electric Switch Corp., Columbus, Ind.

OVERFEED COAL STOKER

COAL from screw conveyors (in pipe) falls into hopper onto 2 revolving distributor heads operated through reduction gears by a small motor. Centrifugal force distributes coal over entire grate surface. Stoker may be swung away from heating plant to allow removal of ashes. Evenness of distribution said to give high efficiency. Fully automatic.

Kirby Mfg. Co., 238 South Union St., Decatur, Ill.



WIRE STRIPPER

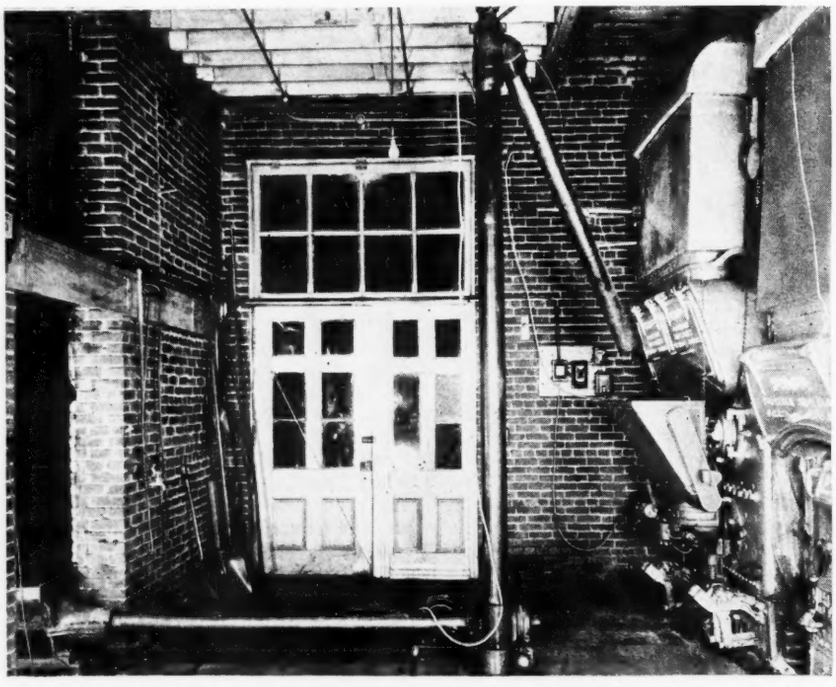
SPRINGLESS unit strips either from left to right or right to left. Double-edge blades in stripping chamber close to within 0.001 in. of diameter set by dialed micrometer gage, strip insulation, twist wire and polish. Powered by ¼-hp. electric motor. Flexible metal tube carries waste strippings to disposal container.

Ideal Commutator Dresser Co., 1025 Park Ave., Sycamore, Ill.

HEATING-SYSTEM CONTROL

"RADIOSTAT" consists of power transformer, secondary windings of which supply potentials to a full-wave rectifier tube and a thyratron tube. Rectified d.c. operates through a Wheatstone-bridge circuit to control thyratron tube with associated relay which controls stoker motor. Resistance coils are mounted on outside of building, in boiler water, in return line from radiators and form parts of circuit. Unit operates stoker intermittently, furnishing just enough steam to balance heat input to radiators with heat loss to outside atmosphere.

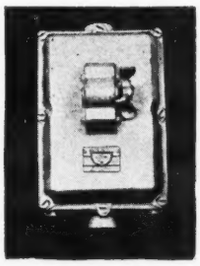
Gaylord Mfg. Co., 1227 Washington Blvd., Chicago, Ill.



EXPLOSION-PROOF MOTOR STARTERS

FOR CONTROL and protection of single-phase and polyphase squirrel-cage motors, Westinghouse manual across-the-line starters provide overload protection with disk thermostat. Quick make-and-break toggle-type mechanism, trip-free handle, front operated. Ratings varied by changing heaters.

Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.



ELECTRIC COUNTERS

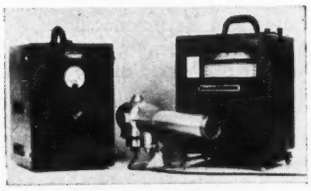
EITHER reset or non-reset, 5-digit counter has constant load on operating mechanism. Indicating wheels are geared together, eliminating tendency for counter to skip. Only 1 number appears on dial at a time.

Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa.

TEMPERATURE RECORDER

"ELECTRONIC INSTAGRAPH," a 3-part unit: thermo-photronic tube, potentiometer amplifier and recorder. Photronic cell, responsive to thermal spectrum of a heated mass, reacts to spectrum by generating small electromotive force, which is measured, amplified, and recorded in terms of temperature. Illustration shows tube at center, amplifier at left, and recorder at right. Recorder uses strip-type chart with range of 0 to 2250 deg. F. Approximate total weight 80 lb. Bulletin 476.

Bristol Co., Waterbury, Conn.



FRACTIONAL-HORSEPOWER DRUM CONTROLLERS

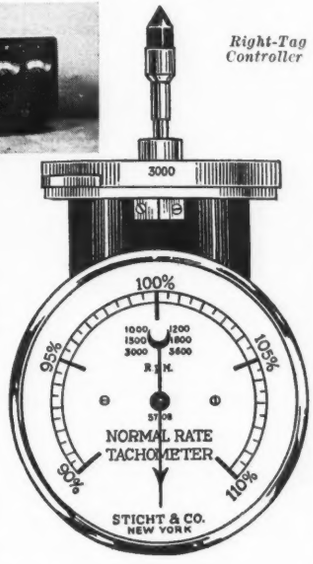
FOR REVERSIBLE a.c. squirrel-cage motors, reversible or non-reversible multi-speed squirrel cage motors, machine tools, etc. "Airstyled" removable case; insulated cylinder to which segments are secured without screws; non-stubbing, renewable contact fingers mounted in individual Bakelite moldings; positive, self-indexing drum.

Cutler-Hammer Inc., 294 N. 12th St., Milwaukee, Wis.

TEMPERATURE CONTROLLER

"TAG" self-operating controller for industrial applications where close control obtainable with auxiliary power is not necessary or where steam pressure is less than 10 lb. Temperature range of 75 deg. between limits of 30 and 450 deg. F. Semi-balanced valves, ½- to 2-in. sizes. Flexible seamless-metal bellows. Bulletin 1142.

C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.



Right-Tag Controller

TACHOMETER

TWO MODELS: No. 500 for 25- and 50-cycle a.c., range of 750 to 6,000 r.p.m.; No. 501 for 50- and 60-cycle a.c., range of 1,000 to 3,600 r.p.m. Dial graduation is in percentage, normal speed indicated by 100%. Set to desired speed by rotating cover until appropriate figure comes in line with index.

Herman H. Sticht & Co., 27 Park Pl., New York, N. Y.

GLOBE AND ANGLE VALVES *(photo below)*

COMPLETING a line of bronze valves, 1¼-, 1½- and 2-in. sizes have hard, stainless-steel seats and disks. Valve trim is heat-treated to 500 Brinell. Illustration shows a steel nail which makers state was crushed between seat and disk of 2-in. valve.

Hancock Valve Div., Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

TIME-CYCLE CONTROLLERS

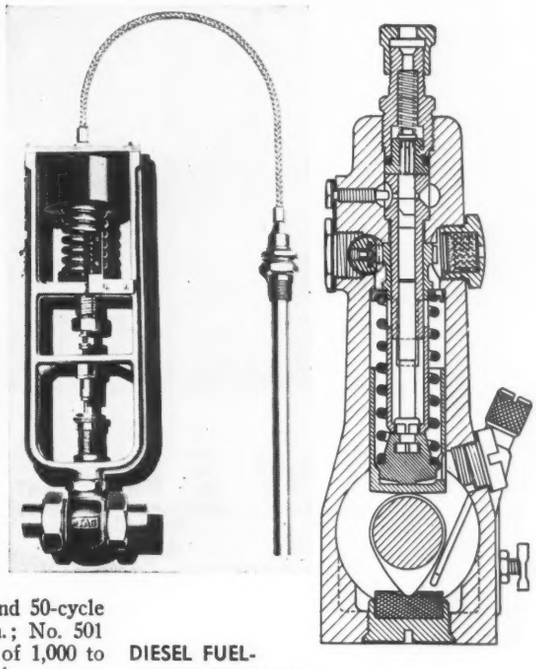
TWO MODELS, have Bakelite cams, terminal panels for motor and circuit connections, 15-amp. "Staley" mercury switches, which on 110-volt non-inductive load circuit have capacity of 1,650 watts. Model 611 operates 1 or 2 circuits at 15, 30, 45 or 60 makes and breaks per min., model 602 for more complex speeds.

Electric Switch Corp., Columbus, Ind.

PIPE FITTINGS

ELIMINATES cutting to exact lengths, threading, grooving, and flaring. Plain-end pipe is inserted into fitting, 2 threaded octagonal follower nuts are tightened, and gaskets at each end of fitting are compressed around pipe, forming positive seal. Resulting joint said to be permanently tight, to absorb vibration, expansion and contraction, and permit deflection of pipe.

S. R. Dresser Mfg. Co., 718 Fisher Ave., Bradford, Pa.



DIESEL FUEL-INJECTION PUMP

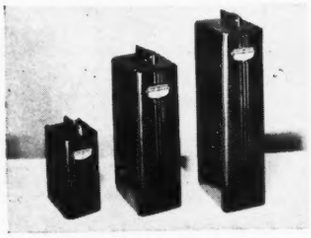
TWO MODELS for 1-, 2- and 6-cyl. engines. High-speed, solid-injection, helical-plunger pumps operated by constant-velocity cams. At low position of plunger, cylinder receives oil charge from feed line, and as piston covers inlet port, fuel delivery starts and ends when upper helical edge of annular piston groove opens bypass port, releasing pressure to discharge line. Delivery regulated by turning piston in cylinder to vary point of delivery stroke in which bypass port is uncovered. Small model for engines up to 150 hp. 4,000 r.p.m.; larger for 110 to 250 hp. and 3,000 r.p.m.

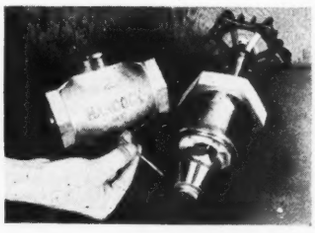
Timken Roller Bearing Co., Canton, Ohio.

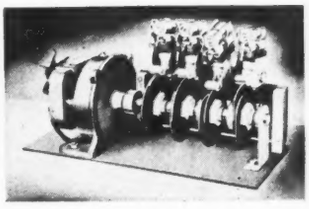
SCREW TAKE-UP

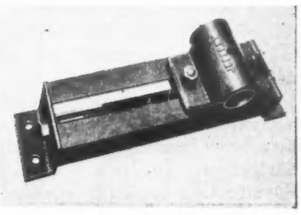
FOR CONVEYORS and elevators, this mechanism has adjusting screw protected from dust and dirt by inverted U-shaped shield. Sliding-base casting, carrying bronze adjusting nut, is cored out to slide freely over shield. Adjusting screw remains stationary inside steel frame.

Jeffrey Mfg. Co., Columbus, Ohio.









AIR-CONDITIONING SILVER JUBILEE

Willis H. Carrier, chairman of the board of Carrier Corp., Newark, N. J., reads a 100-page book filled with messages congratulating him on the 25th anniversary of the presentation of his Rational Psychrometric Formulas, foundation of air-conditioning science. Greetings and honors were received from all over the world.

POWER LINES

New Jersey Public Service Co. Enlarges Essex Station

Orders have been placed by Public Service Electric & Gas Co., Newark, N. J., for a 50,000-kw. turbine-generator and two high-pressure, high-temperature steam boilers to be installed at the Essex generating station in Newark. This will increase the station's generating capacity from 193,000 to 243,000 kw. Boilers will be operated at 1,400 lb. pressure and at a temperature of 950 deg. F., the highest combined temperature and pressure ever to be utilized in a generating station in this country. The turbine-generator will be built by General Electric and boilers by Babcock & Wilcox.

Boilers will be equipped to burn either oil or pulverized coal, and each will have a capacity of 605,000 lb. of steam per hr. It is expected that equipment will be ready for operation about April, 1938.

Hays Takes Over Carrick

Hays Corp., Michigan City, Ind., has taken over the business and personnel of Carrick Engrg. Co., which will be operated as the Carrick Combustion Control Division of the Hays Corp. There will be no change in personnel, and W. H. Pugsley will be manager of the new division. Carrick moved from Chicago to Michigan City several years ago, and Hays Corp. has provided office space and manufacturing facilities for unified instrument and control equipment for steam power plants.

There will be few changes in field representation, as Hays and Carrick products have been handled from the same office in most cities. In New York City, Paul B. Huyette Co., Inc., 205 E. 42nd St., Hays' representative, Andrew Bittner, district manager, doubled office space and took over the Carrick account March 1, and will be assisted by L. R. Merritt Co., for many years Carrick representative in New York City.

Papers Presented at A.S.T.M. Regional Meeting

Two technical symposiums, one on lubricants and the other on corrosion testing, were the features of the 1937 A.S.T.M. Regional Meeting held at the Palmer House, Chicago, March 2 and 3.

In the symposium on lubricants, the first paper presented was "Engine Deposits—Causes and Effects", by Dr. W. A. Gruse, Senior Fellow, Mellon Institute of Industrial Research. This covered sludge, ring sticking, and other oil deposits formed in an engine. A. J. Underwood, assistant head of the Power Plant Dept., General Motors Corp., Research Laboratories Section, presented the second paper on "Automotive Bearings—Effect of Design and Composition on Lubrication."

The third paper was given by Dr. G. M. Maverick, Standard Oil Co. of New Jersey, on "Addition Agents for Lubricating Oils", which included such materials as pour-point depressors, viscosity-index modifiers, oiliness-addition agents, oxidation inhibitors, etc. The concluding paper on lubrication was a brief summary on "How to Select a Motor Oil from the Standpoint of the Consumer", by Dr. W. S. James, Chief Engineer, Studebaker Corp.

Six papers were presented on corrosion testing: "Principles of Corrosion Mechanism and Testing", by R. B. Mears, Aluminum Co. of America, and C. W. Borgman, National Tube Co.; "Atmospheric Testing", by H. S. Rawdon, National Bureau of Standards; "Salt-Spray Testing", by E. H. Dix, Jr., Aluminum Co. of America; "Intermittent Immersion Testing", by D. K. Crampton, Chase Brass & Copper Co., Inc.; "Total Immersion Testing", by R. J. McKay, W. A. Wesley and F. L. LaQue, International Nickel Co.; and "Soil Corrosion Testing", by K. H. Logan, I. A. Dennison and Scott Ewing, National Bureau of Standards.

Pullman Fire Loss Small

In Jan. *Power*, page 57, it was stated that the Pullman Standard Car Mfg. Co., Worcester, Mass., was rebuilding its power plant at the local car-manufacturing plant, destroyed by a $60,000 fire.

A. W. Barker, vice-president of that company, states that the fire was of a very minor nature, and that it suspended operations only for a 24-hr. period necessary for emergency repairs. Total damage was about $5,000, not $60,000.

Here's A Good Idea

The world pays for an idea, and for 89 ideas in 12 years—well, General Electric thinks it's a good idea. Mrs. Sophia Baikusis, a widow with two small children, started work in the GE plant at Schenectady 12 years ago, following the death of her husband. Feb. 26 she was honored with a Charles A. Coffin Foundatioin award, the highest honor General Electric bestows on its employees. She has offered no less than 89 suggestions for improved manufacturing methods, 54 of which have been accepted by the company as worth while.

For each of the 54 accepted suggestions, Mrs. Baikusis received a cash award under the company's suggestion plan; and for being the company's best woman suggestor, she has now received the Coffin Foundation award.

N.A.P.E. Power Show

Announcement has been made by N.A.P.E. of its forthcoming Mississippi Valley Mechanical and Electric Show, to be held at the Jefferson Hotel in St. Louis, Mo., Aug. 30 to Sept. 3. Present indications point to a record-breaking attendance, according to Fred C. Laufketter, chairman of the N.A.P.E. Convention Committee. Out of 100 display booths, 85 have already been taken.

MEETINGS

A.I.E.E.—*Annual Summer Convention, June 21-25, Milwaukee, Wis. H. H. Henline, national secretary.*

A.S.M.E.—*Semi-Annual Meeting, May 17-21, Hotel Statler, Detroit, Mich. Sabin Crocker, Secretary Detroit Committee, in charge.*

Greater New York Safety Council—*8th Annual Convention, April 13-15, Astor Hotel, New York, N. Y. John Stilwell, vice-president, in charge.*

N.A.P.E.—*Mississippi Valley Mechanical and Electrical Show, Aug. 30 to Sept. 3, Jefferson Hotel, St. Louis, Mo. Fred C. Laufketter, chairman of N.A.P.E. Convention Committee.*

Smoke Prevention Assn. and Fuel Burning & Air Pollution Exhibition—*31st Annual Convention, May 31-June 5, Hotel Pennsylvania, New York, N. Y. Frank A. Chambers, secretary-treasurer of S.P.A. and smoke inspector of Chicago, in charge.*

Sale of TVA Power To Aluminum Co.

Federal Judge John Gore at Knoxville, Tenn., Feb. 4 modified his injunction against TVA to permit sale and transmission of electric power to Aluminum Co. of America and its subsidiaries over a line from Norris Dam.

Modification was made at the request of Aluminum Co., which contracted with TVA for electricity before the Gore injunction became effective. Under the contract, TVA will get power from Aluminum Co.'s hydroelectric power dams in North Carolina for use in building Hiwasse Dam, while Aluminum Co., under the modification order, is allowed to purchase any designated quantity of electricity from TVA.

Boiler Explosions in Canada, Chicago

Power and water supply for the town of Field, B.C., were recently cut off as a result of a boiler explosion causing $100,000 damage at the Canadian Pacific Railway shops. A large stationary boiler exploded, wrecking the power house in which it was housed and a nearby storehouse. The boiler crashed through a brick wall, landed against the power-house chimney, which cracked and shattered. Cause of the blast was unknown.

And more recently, on March 2, a boiler-room explosion occurred at the South Chicago works of the Carnegie-Illinois Steel Corp. The entire works was shut down because of the explosion, in which one worker was killed and eight burned.

OBITUARIES

EMERSON PITT HARRIS, 83, pioneer publisher of trade publications and co-founder of *Power* with Horace M. Swetland, died at his home in Franklinville, N. Y., Feb. 17, after a lingering illness of several years. Mr. Harris retired from the publishing field 20 years ago.

FRED L. HOUGH, 54, formerly mechanical design engineer with Brooklyn Edison Co., died Jan. 29 in Dunedin, Fla.

WILLIAM A. REED, 92, former president of the Fall River (Mass.) Steam & Brass Pipe Co., died in that city Feb. 23.

JOHN HENRY BESS, 79, retired chief engineer of Lyons Knitting Mills, Needham, Mass., for 50 years in the employ of that concern, died in Needham, Feb. 12.

FREDERICK A. SCHEFFLER, 79, one of the founders of the Edison Pioneers and long prominent in electrical and mechanical fields, died at his home in Glen Ridge, N. J., Feb. 24. He installed the first individual electric plants in New York City.

ARTHUR K. OHMES, 62, consulting engineer and leader in the heating and ventilating field, died at his home in Hasbrouck Heights, N. J., Feb. 11, after a short illness from pneumonia. Mr. Ohmes designed heating and ventilating equipment for such New York buildings as Bellevue Hospital, Pennsylvania Hotel, Metropolitan Museum of Art and Museum of Natural History.

GEORGE E. WOODHOUSE, 57, Superintendent of the Toronto District, Ontario Hydroelectric Power Commission, died Feb. 21.

WARREN H. JONES, 61, Secretary, Assistant Treasurer and a Director of Westinghouse Electric & Mfg. Co., died of pneumonia recently in Mount Vernon, Pa. Mr. Jones had been associated with Westinghouse for the past 26 years.

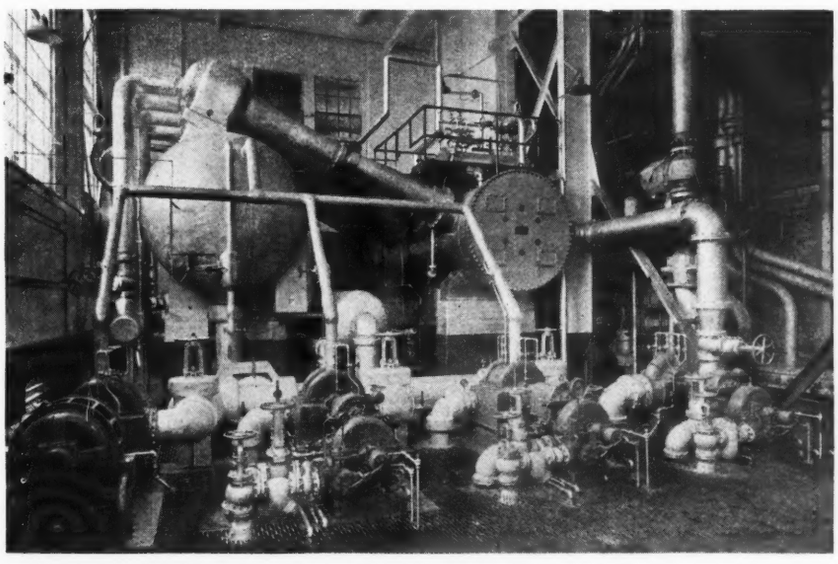
A. C. LOOTZ, 66, since 1922 engineer in charge of plant operation, maintenance, and construction at Mass. General Hospital, Boston, died Feb. 21 after a brief illness.

H. L. WILLS, 70, consulting engineer, and prominently identified with the public utility industry in Georgia, died at his home in Atlanta, Jan. 21. He held many operating and executive positions with Georgia Power Co. and predecessor companies.

PROF. ELIHU THOMSON, 83, one of the founders of General Electric Co., died at his home in Swampscott, Mass., March 13. He had been ill since January.

VACUUM-REFRIGERATION UNIT

Firestone Tire & Rubber Co. uses this unit in its Los Angeles plant to cool 2,000 g.p.m. of process water from 70 to 60 deg. F. High-pressure steam supply for operating this cooling unit is taken from the exhaust of a back-pressure turbine that discharges into a Foster Wheeler evaporator



PERSONALS

CHESTER W. DIBBLE

BACK in 1887, the publishers of *Power* were hunting an office boy. They finally hired Chester W. Dibble at the princely salary of $2.50 a week. He carried their silk hats to be ironed. He operated the rope elevator that carried made-up forms to the ground so they could be carted around the corner to the printer (once one dropped and fell into a scrambled heap of type metal). He tended fires in stoves, bought stamps, carried lunches—and spent the usual amount of time watching the printer's Baxter steam engine (the engine was sunk into the top of a vertical boiler). He even lent the partners (*Power* was then only five years old) part of his pay to buy stationery.

Eventually his familiarity with the printer's engine stood him in good stead—he was made assistant editor and started to grow a moustache. The man who had followed him onto the *Power* staff by a little over a year began to send him out to get stories. The man was Fred R. Low, and Chester Dibble was associated with him continuously until Mr. Low's retirement. He it was who got many of *Power's* early stories on boiler explosions, complete with pictures, even though once he had to get to the scene by riding the caboose of a freight train.

Later, Mr. Dibble went on to become assistant business manager, in charge of advertising arrangement on the magazine. March 15 of this year marked his fiftieth year of service.

But Chester Dibble didn't come to work March 15, because on March 5 he sailed aboard the *President Polk* for the Panama Canal and West Coast to take a well-earned vacation, with all expenses paid and a pair of new binoculars over his shoulder, the gift of his associates.

HERBERT B. REYNOLDS has been made mechanical engineer in charge of consolidated Mechanical Operating and Mechanical Engineering Divisions of the Motive Power Department of New York City's Interborough Rapid Transit Co. In this position, he is responsible for mechanical engineering, maintenance and operation of two power stations with generator capacity of 400,000 kw.

C. W. POMEROY has been elected secretary of Westinghouse Electric & Mfg. Co., to fill a vacancy left by death of Warren H. Jones. Mr. Pomeroy has been with Westinghouse since 1919, and since 1934 as supervisor of foreign licenses.

JAMES G. MARSHALL, general superintendent of Niagara and Welland plants of Union Carbide Co. and Electro Metallurgical Co., has been awarded the Jacob F. Schoellkopf Medal for 1937, awarded annually by the American Chemical Society. Formal presentation will not be made until early in October as Mr. Marshall will be abroad in May, when the award is usually made. Mr. Marshall is the inventor of a successful reciprocating drag conveyor for furnace mixture of lime and coke.

S. B. WHINERY, 1 Hudson St., New York, N. Y. has been appointed New York sales manager and H. C. Stevens, formerly with United Piece Dye Works, New York service engineer for Cyrus Wm. Rice & Co., Inc., Pittsburgh, Pa.

W. E. PERKINS, vice-president in charge of American Hammered Piston Ring and Bartlett Hayward Divisions of Koppers Co., has been put in charge of the company's Western Gas Division in Fort Wayne, Ind.

E. R. GAVIN, for the past year assistant sales manager for Caterpillar Tractor Co., has been promoted to general sales manager.

HARLAN W. HOW has rejoined Struthers Wells-Titusville Corp., Titusville, Pa., as technical director. He was formerly chief engineer of Buffalo Foundry & Machine Co. and, lately, consulting engineer for Blaw Knox Co. at Pittsburgh.

ROBERT GEORGE WATSON, consulting engineer of Toronto, Ont., has been appointed superintendent and chief engineer to municipal power plant at Edmonton, Alberta.

STANLEY W. CANNITT was recently named general manager of Ottawa Hydro-electric Commission to succeed John E. Brown, who retired after 30 years service.

A. RITCHIE, formerly chief engineer of Edmonton (Alta.) Power Co., has accepted a position with Whiting Corp. of Canada, Ltd.

PAUL HAYDEN recently joined field staff of Hancock Valve Division of Consolidated Ashcroft Hancock Co., Bridgeport, Conn. Mr. Hayden will be stationed in the South.

ALEX SPEER, president of Florida Power Corp. for the past 8 years, has been elected president of Virginia Public Service Co., with headquarters at Alexandria, Va. He succeeds J. S. Avery, who is moving to New York City to become vice-president of Utility Management Corp. A. W. Higgins, since early 1936 vice-president of Utility Management Corp., will assume charge of Florida and Georgia properties of Associated Gas & Electric System and has been elected president of Florida Power Corp. to succeed Mr. Speer.

FREDERICK P. FAIRCHILD, assistant engineer since Nov. 1, 1936, has been promoted to chief engineer of Public Service Electric & Gas Co., Newark, N. J., succeeding Edward B. Meyer who died Jan. 30.

WILLIAM J. O'NEILL, sales manager, Chicago factory branch, Iron Fireman Mfg. Co., was elected president of Midwest Stoker Assn., at its annual meeting held in Chicago, Feb. 9. Mr. O'Neill succeeds J. E. Martin, manager stoker division, Link-Belt Co., who held presidency of the organization for two years.

DR. FRANK CONRAD, assistant chief engineer, Westinghouse Electric & Mfg. Co., will be awarded the 1936 Lamme Medal of the A.I.E.E., "for his pioneering and basic developments in the fields of electric metering and protective systems". Medal and certificate will be presented at the annual A.I.E.E. Summer Convention to be held in Milwaukee, Wis., June 21-25.

WILLIAM H. DRISCOLL, former vice-president in charge of mechanical equipment with Thompson-Starrett Co., is now vice-president in charge of construction for Carrier Corp., Newark, N. J.

R. B. RENNER, for the past 30 years mechanical engineer with Jeffrey Mfg. Co., Columbus, Ohio, was recently made chairman of the executive committee, A.S.M.E. Materials Handling Division.

EDWARD J. FERTIG has joined Paul B. Huyette Co., Inc., as sales engineer, specializing in combustion-control equipment. Offices are located at 205 E. 42nd St., New York, N. Y.

BUSINESS ITEMS

GENERAL CONTROLS Co., Los Angeles, Calif., has opened a New York office at 267 5th Ave. H. G. Wasserlein will act as branch manager.

FOOTE BROS. GEAR & MACHINE CORP., Chicago, Ill., has appointed H. F. Edge & Co., 987 Cox Ave., Atlanta, Ga., as Southeastern district representative.

CATERPILLAR TRACTOR Co., Peoria, Ill., recently announced appointment of Louis B. Neumiller as sales manager of its Central Sales Division. E. W. Jackson has been promoted to general service manager, position held by Mr. Neumiller prior to his advancement.

CROSSMAN ELECTRICAL Co., LTD., has received official sanction to change its name to Crossman Machinery Co., Ltd. Registered offices will continue at 59 Alexander St., Vancouver, B. C.

CRANE Co., Chicago, Ill., has established two new sales districts, East Central and Southeastern, in charge of C. S. Pitkin and J. G. Johns, respectively. Mr. Pitkin has been manager of Crane's Pittsburgh branch since 1922, and Mr. Johns, at Birmingham, since 1920.

IRONTON FIRE BRICK Co., Ironton, Ohio, has announced appointment of Interstate Supply & Equipment Co., Milwaukee, Wis., as sales representative for Wisconsin.

AJAX FLEXIBLE COUPLING Co., Westfield, N. Y., has opened a new sales office in Louisville, Ky., under management of Alfred Halliday.

CRANE PACKING Co., Chicago, Ill., has moved its Houston, Tex., office from 911 Electric Bldg. to 1306 Capitol St., a new factory branch and warehouse.

COCHRANE CORP., Philadelphia, Pa., has consolidated sales in New England under Cochrane Steam Specialty Co., 80 Federal St., Boston, Mass. O. S. Pike will direct sale of water-treatment equipment and T. N. Graser, sale of meters and specialties.

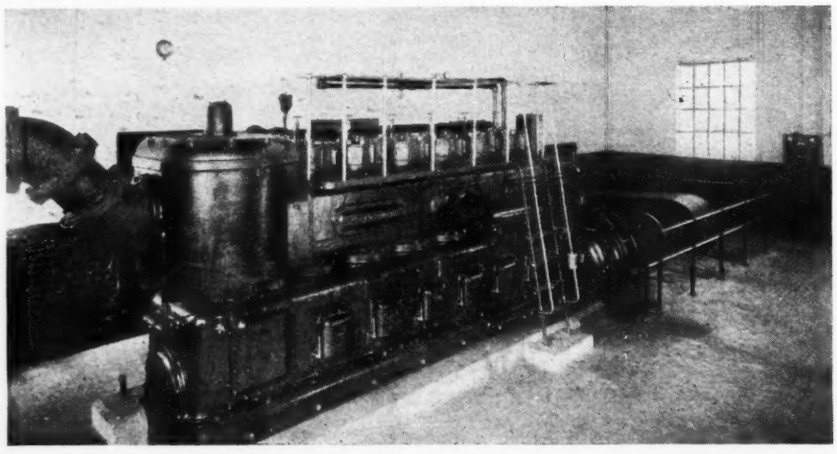
LINCOLN ELECTRIC Co., Cleveland, Ohio, has moved its Cincinnati office to Room 602, American Bldg., Central Parkway at Walnut St., following recent flood conditions of the Ohio River.

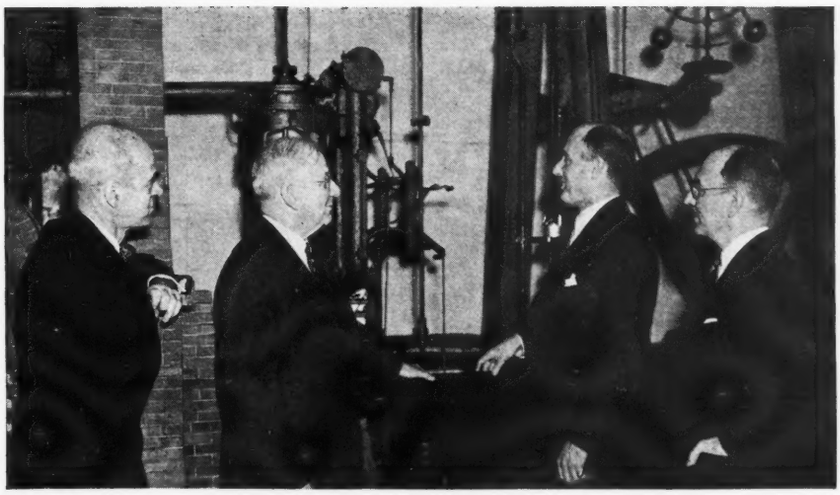
NEW YORK BELTING & PACKING Co., Passaic, N. J., has announced appointment of Biggs-Kurtz Hardware Co., Grand Junction, Colo., as distributors in that area.

JOHN A. ROEBLING'S SONS Co., Trenton, N. J., announce the appointment of Arthur E. Gaynor as manager of their New York branch succeeding W. P. Bowman, deceased.

COTTON-MILL DIESEL

Fairbanks Morse, 6-cyl., 600-hp., 400 r.p.m. diesel powers a 2 press cotton-seed oil mill at Minter City, Miss.





A.S.M.E. OFFICIALS VISIT FRANKLIN INSTITUTE

Left to right: Henry S. Harris, former Chairman of the Philadelphia Section, A.S.M.E.; James H. Herron, A.S.M.E. President; Henry Butler Allen, Secretary and Director of the Franklin Institute; and J. P. Harbeson, present Chairman of the A.S.M.E. Philadelphia Section, looking over a half-size scale model of James Watt's high-pressure, double-acting, Sun-and-Planet condensing engine at the Franklin Institute, Philadelphia

BURLINGTON INSTRUMENT CORP., Burlington, Iowa, has appointed Diesel Plant Specialties Co. representative in Chicago, and Commercial Engrg. Co., Inc., in Washington, D. C.

GEO. P. REINTJES Co., Kansas City, Mo., has appointed J. R. Goodwin, of Dunbar Engrg. Co., 103 Park Avenue, New York, N. Y., as its representative for New York City.

LINK-BELT Co., Chicago, Ill., recently named James Robertson Co., Ltd., as distributors of Link-Belt automatic coal burners in Canada. Headquarters are in Montreal, with branches in Toronto, St. John, Winnipeg and Saskatoon.

ALLEN-BRADLEY Co., Milwaukee, Wis., is now being represented in Kansas City by B. L. McCreary, with offices at 405 E. 13th St. J. W. Briddick, former Kansas City sales agent, has left that city to establish himself in business in Toronto.

C. O. BARTLETT & SNOW Co., Cleveland, Ohio, has appointed Lloyd R. Leatherman representative for coal and ash-handling equipment in Michigan, with offices at 2140 Book Bldg., Detroit.

H. A. BRASSERT & Co., Chicago, Ill., has opened a branch office in the Koppers Bldg., Pittsburgh, Pa.

MINNEAPOLIS-HONEYWELL REGULATOR Co., Minneapolis Minn., recently made an agreement for acquiring complete line of pneumatic controls manufactured by National Regulator Co., Chicago.

FAWICK MFG. Co., Waukesha, Wis., has changed its name to Industrial Clutch Co. Change is in name only; ownership, management and product remaining as before.

IDEAL COMMUTATOR DRESSER Co., Sycamore, Ill., recently acquired Marshall Electric Co. of Elkhart, Ind., makers of automatic regulators for voltage, current and speed control of electrical equipment.

GEO. P. REINTJES Co., Kansas City, Mo., has named Herr-Davis Co., 910 Fulton Bldg., Pittsburgh, Pa., as representative for Pittsburgh area.

SHEFFLER-GROSS Co., INC., Philadelphia, Pa., is now handling American Car & Foundry Co.'s plug valves in Philadelphia and surrounding territory.

MEDART Co., St. Louis, Mo., has opened a district sales office in Kansas City, Mo., in the Dierks Bldg. W. A. Crooks, power-transmission engineer, is in charge.

STARKWEATHER ENGRG. Co., INC., has recently moved from Boston to 246 Walnut St., Newtonville, Mass.

CRERAR, ADAMS & Co., 3550-58 S. Morgan St., Chicago, Ill., has been appointed representative for New York Belting & Packing Co. in Chicago.

TUBE-TURNS, INC., Louisville, Ky., has moved to new and larger quarters at 224 East Broadway, Louisville.

IRON & STEEL PRODUCTS, INC., Chicago, Ill., anounce the resignation of P. K. Freese.

SCHOOLS and SOCIETIES

AMERICAN WELDING SOCIETY has accepted from J. F. Lincoln, president of Lincoln Electric Co., a gold medal to be presented to the author of the best paper on any phase of welding published in A.W.S.'s *Journal* during the year Oct., 1936 to Oct., 1937. No paper will be considered unless it is received by the Editor of the *Journal* before Sept. 15. No restriction will be made as to subject matter; paper may be on electric-arc, gas, resistance or any other form of welding coming under scope of the A.W.S.

COLUMBIA UNIVERSITY SCHOOL OF ENGINEERING is considering a 5-year plan for extending its physical facilities, outlined by Dean Joseph W. Barker in his annual report to President Nicholas Murray Butler. The program, which calls for construction of two new buildings, would involve no increase in the engineering student body, but would "care for technical advances which have been made in the various fields of engineering in the past three decades."

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Cambridge, Mass., will hold a special summer school and conference on strength of materials for four weeks beginning June 21. Admission to the school will be in order of application. Full particulars may be obtained by communicating with Prof. J. M. Lessells, Dept. of Mechanical Engineering, M.I.T.

SOCIETY FOR PROMOTION OF ENGINEERING EDUCATION, Mechanical Engineering Division, will hold a conference on June 28 and 29 in Cambridge, Mass., to consider various phases of teaching mechanical engineering. This conference will precede the anual meeting of S.P.E.E., to be held from June 29 to July 2, with M.I.T. and Harvard as hosts.

STRAWS

Pointing the way business winds blow

BANGOR HYDROELECTRIC Co., Bangor, Me., will spend $5,000,000 during next 5 yr. in a long-range power-expansion program.

NEW ENGLAND PUBLIC SERVICE Co., on behalf of Cumberland County Power & Light Co., Portland, Me., will shortly build a hydroelectric plant at Saco, Me., to have a vertical unit of 9,500 kva. under 44-ft. head. General Electric has received contract for 3-phase, 11-kv. generators.

YORK ICE MACHINERY CORP., York, Pa., has just received a contract to install what is said to be world's largest air-conditioning refrigerating plant in Capitol Power Plant Bldg., Washington, D. C., 6,000 hp. will be required to supply 11,500,000 g.p.d. of chilled water to the Capitol, Senate Office Bldg., and new and old House of Representative, Office Bldgs.

COHEN MACHINERY Co., Manchester, N. H., has purchased former No. 4 Canal building, south, from Amoskeag Mfg. Co., for expanding its business of electric motors, new and rebuilt, and other mill machinery.

HOPE NATURAL GAS Co., 545 William Penn-Way, Pittsburgh, Pa., has authorized surveys for welded-steel pipeline from Ohio River south of Bellaire, Ohio to Cleveland, Ohio.

BOARD OF EDUCATION, Springfield, Mass., plans central heating plant in new multistory trade school. Cost about $950,000. Frank W. S. King, 33 Lyman St., architect.

SOUTH

WINSTON-SALEM, N. C., plans $30,000 extensions in ice and cold-storage plant. Company recently acquired by new interests, headed by J. T. Doster, 2707 Hanover Circle, Oxford, and will be known as Oxford Ice & Fuel Co.

JACKSON, TENN., is considering a $364,000 electric power distribution project.

GREENSBORO ICE & COAL CO., Greensboro, N. C., has acquired local ice-manufacturing and refrigerating plant of Greensboro Ice & Fuel Co., on Prescott St., and will remodel and increase capacity. Cost close to $40,000. George S. Sherrod, president.

CONTINENTAL BAKING CO., Shreveport, La., is considering boiler equipment, traveling ovens, air-conditioning equipment and other mechanical equipment in local baking plant additions. Cost close to $90,000. Henry W. Weiche, manager.

PURE ICE & PROVISION CO., 2500 Wheat St., Columbia, S. C., plans 1-story cold storage and refrigerating plant. Cost close to $45,000, with equipment. George H. Dieter, president.

MOUNT VERNON, INC., Marianna, Fla., recently chartered, plans hydroelectric plant on Chipola River, Calhoun County. Project will include dam, generating station of 20,000 hp. initial capacity, with high-tension lines to Mount Vernon, Marianna, Port St. Joe and other communities. Cost over $150,000. Application has been made for Federal permission.

SOUTHERN PACIFIC FREIGHT TERMINAL, 150 Poydras St., New Orleans, La., plans cold-storage and refrigerating plant unit. Cost about $60,000, with equipment. Leo S. Weil and Walter B. Moses, 427 South Peters St., engineers. Work will begin soon.

TAMPA STORAGE & WAREHOUSE CO. plans new cold-storage and refrigerating plant at 320 South Miami Ave., Miami, Fla. Cost about $80,000.

HARRISONBURG, LA., plans municipal electric and ice-manufacturing plant. Part of financing, totaling $22,000, through Federal aid. T. L. McGuffee, mayor, active in project.

CAMPBELL COUNTY BOARD OF SUPERVISORS, Rustburg, Va., plans central heating plant in Courthouse Square area. Financing through Federal aid. C. H. Hinnant, Peoples' National Bank Bldg., Lynchburg, Va., architect.

MERIDIAN, MISS., plans municipal cold storage and refrigerating plant. Cost about $150,000. Financing through Federal aid.

J. S. WEEKS & CO., Charleston, S. C., plan 1-story cold storage and refrigerating plant at 86 Market St. Cost about $35,000.

PORTSMOUTH, VA., B. T. Harper, city manager, has preliminary plans for municipal power plant, including substation and distribution facilities. Cost estimated $2,000,000, through Federal aid.

HARRISONBURG, VA., contracted Westinghouse for 2000-kw. generator and auxiliaries for municipal power plant. Also Edge Moor Iron Co., Edgemoor, Del., for 5000-sq.ft. boiler. Research Service, Chandler Bldg., Washington, D. C., consulting engineer.

NORMAN MILLING CO., Calvert City, Ky., plans rebuilding of steam-electric station recently destroyed by fire. Loss reported over $75,000, including that to mill.

SOUTHWEST

SKELLY OIL CO. has contracted Truman Smith Construction Co. for Lindewelded 20-mile extension from present 6-in. oil line at Lorraine, Kan.

KELLEY, DEMPSEY & CO. will build 7 miles of Lindewelded 10-in. oil line for Gulf Refining Co., near Eunice, N. M.

BLACKWELL, OKLA., plans expansion at municipal power plant, including boiler unit and auxiliaries. Fund of $50,000 authorized. E. E. Tierney, superintendent.

PURE OIL CO. has let contract to B & M Construction Corp. for 4-in., Lindewelded oil line from Edmond, Okla., to Oklahoma City.

DIXON PACKING CO., 108 Milam St., Houston, Tex., plan boiler plant at new food-products packing and canning plant. Cost close to $150,000. S. F. Dixon, president.

TEXAS CO., 929 South Broadway, Los Angeles, Calif., plans boiler plant at gasoline processing plant near Fillmore, Calif. Also compressor units, cooling towers, etc. Cost over $150,000.

SEVEN-NOSED MONSTER

Arc-welded inlet manifold to the Gene pumping station on the $236,000,000 Colorado River Metropolitan District Aqueduct, scheduled for completion next year. The giant arc-welded steel pipe, fabricated by Consolidated Steel Corp., Los Angeles, Calif., will have an eventual capacity of one billion gallons of water per day— ***Lincoln Electric Co. Photo***

ARIZONA EDISON CO., Douglas, Ariz., has approved plans for extensions and improvements in water system at Coolidge, Ariz., including addition to waterworks station and new diesel unit and accessories, for standby service, and 100,000-gal. elevated steel tank and tower. Cost close to $50,000. J. B. Sexton, company manager.

BLYTHEVILLE INDUSTRIAL ASSN., INC., Blytheville, Ark., plans boiler plant at new local factory to be constructed for Rice-Stix Dry Goods Co., 1000 Washington St., St. Louis, Mo. Cost about $80,000. Bids soon.

GULF STATES UTILITIES CO. recently contracted Westinghouse for a $500,000 turbine as initial step in long-range expansion program. A 27,500-kw. unit will be added to present 57,000-kw. capacity of Neches River plant at Beaumont, Tex.

WHITE DEERE PIPE LINE CONSTRUCTION CO. has been awarded a contract by Anderson Pritchard Oil Co. to build a 12-mile, Lindewelded 4-in. oil line from Moore, Okla., to booster station southeast of Oklahoma City.

PHILLIPS PETROLEUM CO. has awarded contract to J. F. Pritchard & Co. for extensive system of gas-gathering lines near Eunice, N. M.

SISTERS OF CHARITY OF INCARNATE WORD, Houston, Tex., care of I. E. Loveless, 102 South Robertson St., Beverly Hills, Los Angeles, Calif., architect, will build a steam power plant at new 5-story and basement hospital at Houston. Cost about $750,000.

ROCKWELL COUNTY LIGHT & POWER CO., Rockwell, Tex., plans steam-electric plant to include three 900-hp. diesel units. Bids will be asked soon. Cost about $275,000, of which approximately $200,000 through Federal financing. William G. Morrison, Professional Bldg., Waco, Tex., consulting engineer.

MIDWEST

CLYDE, OHIO, contracted Elliott Co., Jeannette, Pa., for turbines and condensers for municipal power plant. Award for switchgear has been made to Westinghouse.

WATERLOO, IOWA, plans electric-operated pumping station at new sewage disposal plant. Bids will be asked in near future. Cost about $1,000,000. C. T. Wilson, city engineer, in charge.

NATIONAL AUTOMOTIVE FIBRES, INC., 19925 Hoover St., Detroit, Mich., plans boiler house at new branch plant, 5000 Randolph St., Los Angeles, Calif. Cost about $250,000. Harry T. Miller, 4814 Loma Vista Ave., Los Angeles, architect.

GRAND HAVEN, MICH., has contracted Nordberg Co., Milwaukee, Wis., for 1500-kw. diesel-engine-generator unit for municipal electric plant, as part of expansion program. Cost about $135,000.

FIRESTONE TIRE & RUBBER CO., Akron, Ohio, plans power plant at new multi-unit automobile tire and tube manufacturing plant near Wyandotte, Mich. Work will begin in the spring. Cost over $2,500,000. A pumping plant will be built.

GLENCOE, MINN., contracted Fairbanks, Morse & Co., Chicago, Ill., for diesel engine-generator unit and auxiliaries municipal plant. General contract has been let to Bladholm Construction Co., Marshall, Minn., for power station building, and to Donovan Construction Co., 1725 Carroll Ave., St. Paul, Minn., for electrical distribution lines. G. M. Orr & Co., Baker Arcade Bldg., Minneapolis, Minn., consulting engineers.

BOARD OF CONTROL OF STATE INSTITUTIONS, Des Moines, Iowa, is arranging appropriation of about $2,000,000 for new buildings, utilities, extensions and improvements in State institutions in 1937, including rebuilding of power house at institution at Cherokee, to cost about $125,000; new engine-generator unit, boilers, stokers, elevated steel tank and tower, for power house at Oakdale, cost about $85,000; new cold storage and refrigerating plant, and elevated steel tank and tower for water system at institution at Clarinda, cost over $65,000; new engine-generator unit, boiler and accessory equipment for power house at Woodward, cost about $45,000; reconstruction of boiler house at hospital at Mount Pleasant, and installation of boilers, stokers, pumps and auxiliary equipment, cost about $120,000. State architect in charge of plans.

GLADSTONE, MICH., will submit plans soon for a $105,000 electric light and power improvement project.

KENDALLVILLE, IND., is planning vertical-lift pumping machinery and auxiliary equipment for municipal sewerage system. R. S. Ludlow, superintendent of power and light department, in charge.

HOLDREGE, NEB., plans enlarging capacity of municipal electric plant. Bids will be asked soon. Cost about $100,000. Black & Veatch, 4706 Broadway, Kansas City, Mo., consulting engineers.

BRANDWEIN CO., 2349 South State St., Chicago, Ill., plans improvements in steam power house at local mattress factory. Work will be carried out in connection with new plant addition, entire project to cost amout $100,000. A. Epstein, 4001 West Pershing Rd., engineer.

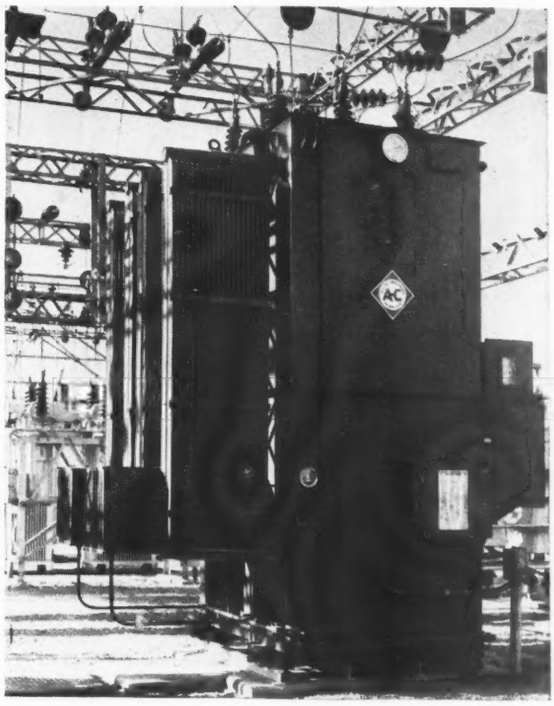
BOARD OF WATER COMMISSIONERS, Sheboygan, Wis., contracted Acker Electric Co., Sheboygan, for two motor-driven centrifugal pumping units for waterworks station, at $17,697.

VIRGINIA, MINN., contracted General Electric Co. for turbo-generator unit and auxiliaries for municipal plant, at $65,000; also let contract to Western Electric Co., Minneapolis, Minn., for surface condenser.

NICHOLS-FOSS PACKING CO., Bay City, Mich., plans steam power house, 40x60 ft., at new local food-products packing and canning plant. To begin work soon. Cost about $80,000.

STATE HOSPITAL, LOGANSPORT, IND., Dr. C. L. Williams, superintendent, contracted Springfield Boiler Co., Springfield, Ill., for boilers and accessories, and Laclede Co., St. Louis, Mo., for stokers, for power house at institution, for which erection contract has been let to A. J. Wolf Construction Co., Logansport. To purchase coal and ash-handling equipment in near future. Cost about $134,000. Bevington-Williams, Inc., Indiana Pythian Bldg., Indianapolis, Ind., consulting engineer.

STEP TRANSFORMER



One of the large high-voltage, step-type, regulating transformers built in 1936. This one, by Allis-Chalmers, is rated 1,333 kva., 46,000 volts, 3-phase, and is designed for plus or minus 10% regulation in 32 0.6% steps.

DEPARTMENT OF PUBLIC WORKS, Detroit, Mich., has low bid at $1,480,199 from S. A. Healy Co., 600 West Van Buren St., Chicago, Ill., general contractor, for waterworks pumping station and auxiliary structures at River Rouge and West Jefferson Ave., and will place award soon.

WHITE EAGLE OIL CORP., Wichita, Kan., is completing plans for new 10-in. welded-steel pipeline to form loop system from point near Valley Center, Kan., to Holloway, Kan., for crude-oil transmission. Booster pumping stations to be built. Cost over $200,000.

PAOLA, KAN., plans municipal electric plant, with initial capacity of about 1,000 kw. Also substation and distribution lines. Extensions in present waterworks station for new power house. Cost about $225,000. W. B. Rollins & Co., Railway Exchange Bldg., consulting engineers.

MACUS, IOWA, plans municipal electric plant and will secure estimates of cost soon. Financing through Federal aid.

PARK RIDGE, ILL., plans electric-operated pumping machinery and auxiliary equipment in connection with waterworks expansion. Fund of $250,000 through Federal aid. Consoer, Townsend & Quinlan, 205 West Wacker Drive, Chicago, Ill., consulting engineers.

ACKLEY, IOWA, has asked bids for extensions in municipal power plant. To install 375-hp. diesel unit, direct-connected to 250-kw., generator, with exciter and complete auxiliary equipment. Cost about $35,000. Ralph W. Gearhart, 341 Twenty-first St., S.E., Cedar Rapids, Iowa, consulting engineer.

FAIRVIEW FARMS & INVESTMENT CO., Telephone Bldg., Kansas City, Mo., Robert J. Ingraham, representative, plans central heating plant at new 5-story and basement factory in Gillham Plaza district. Cost about $450,000. A. H. Gentry, Voskamp & Neville, Inc., 4 West Thirteenth St., architect.

BLACK BROTHERS FLOUR MILL CO., Beatrice, Neb., plans boiler plant in connection with rebuilding of flour and grain mill, recently destroyed by fire. Loss about $150,000.

B. F. GOODRICH CO., Akron, Ohio, has purchased factory site and building at Cadillac, Mich., formerly occupied by Acme Motor Truck Co. Work will begin at once to fit building for manufacture of general line of rubber goods.

LIBBY-OWENS-FORD GLASS CO., Toledo, Ohio, has awarded contract to Stone & Webster Engrg. Corp., for construction of boiler plant and water-intake improvements at Rossford, Ohio, plant. Two existing boilers will be removed and a new 150,000-lb of steam-per-hr. unit operating at 420 lb. pressure and 775 deg. installed. Cost about $600,000.

WEST

LAS VEGAS, NEV., plans municipal power plant and electrical distribution system. Bond issue of $200,000 being arranged. L. L. Arnett, mayor, in charge.

SPOKANE, WASH., plans electric-operated pumping plant for water-supply system. Fund of $330,000 through Federal aid. A. D. Butler, city engineer.

SANTA FE RAILROAD, Union Pacific Railroad and Southern Pacific Railroad, Los Angeles, Calif., plan central heating plant in new multi-unit union passenger terminal on Alameda St. Cost about $2,500,000. A. J. Barclay, 726 North Alameda St., construction superintendent.

DIAMOND ICE CO., 1331 Western Ave., Seattle, Wash., plans improvements in ice-manufacturing plant. Fred F. Weld, Rolling Bay, Wash., consulting engineer.

OGDEN, UTAH, contracted A. C. Todd Co., Salt Lake City, Utah, for municipal electric plant. Will include turbo-generator, high-pressure boiler, pumping machinery. Bond issue of $2,600,000 arranged

ORANGE, CALIF., is considering municipal electric plant. To arrange bond issue of $250,000. A. C. Boice, mayor, active in project.

TOUGH GUY . . .

Everybody admires the boss who occasionally gets down into the grease with the rest of us and figures the way out, the fellow who grits his teeth and keeps on going when it seems hopeless, the "guy who don't know when he's licked."

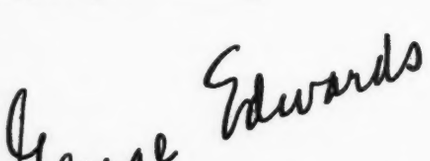
It takes a lot of downright guts to be that kind of a man. No false bluster or big talk will do it; it takes something way down inside when the time comes to deliver the goods. That kind of a man recognizes constructive criticism and profits by it, does what he can to meet the other fellow's point of view without sacrificing his own individuality. He has to be big; pettiness and meanness sooner or later find themselves out.

If your plant organization is wrong, and somebody tells you so, don't fly to its defense before you've heard what he has to say. A too-ready defense means a sensitive spot underneath, just like a prizefighter who's taken one on the button always guards that point regardless of how many openings he leaves elsewhere.

Be ready to admit your mistakes. We all make them. School your organization to do the same thing, and don't tolerate alibis and excuses. That sort of example will help you, and it may make an impression higher up.

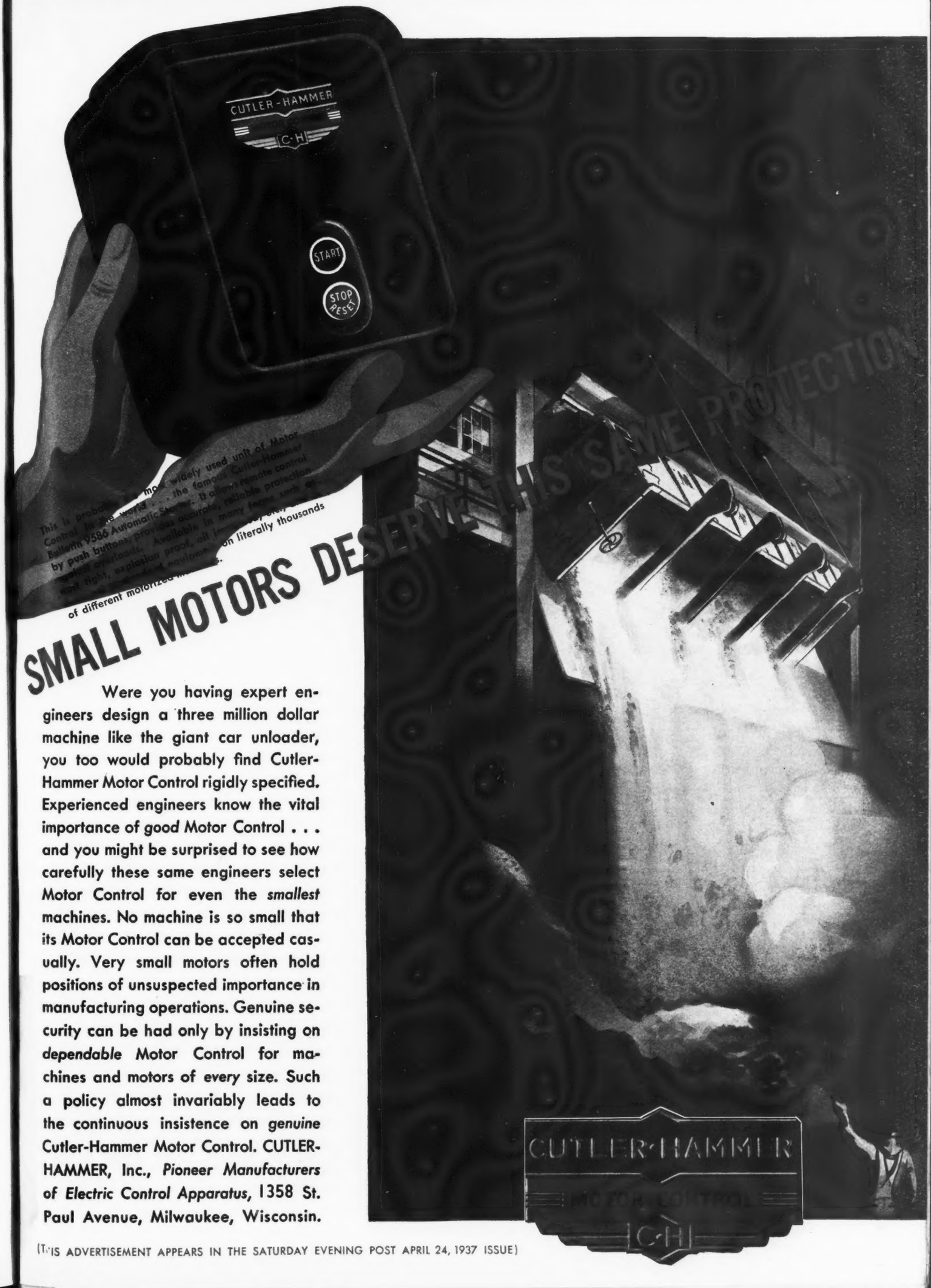
This all reminds me of the typical technical article, the typical society paper, the typical sales talk, all built around one thesis, "Never admit your weaknesses." Yet, the first step towards curing a weakness is to own up to it. You can't cure something you won't admit exists. Why not be honest and open about it? If somebody asks about the troubles you're having, why not admit them, then go on to explain what you're doing about them?

I'm for honest articles, honest ads, honest talks. No shilly-shallying and avoiding the truth with honeyed words and double talk. I'm for more trouble stories, maybe for "true confessions," if that's what you call them, for bringing things out in the open and getting help in fixing it, be it a personal weakness or a boiler explosion. I'm for more tough guys, for organizations as well as individuals who can take it when they've got it coming.



GEORGE EDWARDS,
Engineer

CUTLER-HAMMER MOTOR CONTROL SAFEGUARDS THIS $3,000,000 MACHINE



SMALL MOTORS DESERVE THIS SAME PROTECTION

Were you having expert engineers design a three million dollar machine like the giant car unloader, you too would probably find Cutler-Hammer Motor Control rigidly specified. Experienced engineers know the vital importance of *good* Motor Control . . . and you might be surprised to see how carefully these same engineers select Motor Control for even the *smallest* machines. No machine is so small that its Motor Control can be accepted casually. Very small motors often hold positions of unsuspected importance in manufacturing operations. Genuine security can be had only by insisting on *dependable* Motor Control for machines and motors of *every* size. Such a policy almost invariably leads to the continuous insistence on *genuine* Cutler-Hammer Motor Control. CUTLER-HAMMER, Inc., *Pioneer Manufacturers of Electric Control Apparatus*, 1358 St. Paul Avenue, Milwaukee, Wisconsin.

(THIS ADVERTISEMENT APPEARS IN THE SATURDAY EVENING POST APRIL 24, 1937 ISSUE)

NEW PLANT CONSTRUCTION

McGraw-Hill Business News Department Is Prepared to Furnish a More Complete Daily Service

Calif., Fillmore—Texas Co., 929 South Broadway, Los Angeles, making plans gasoline processing plant, incl. 2 cooling towers, compressor house, boiler house, several distillation units, storage house, etc., 5 mi. south of here. Pipe work, incl. installation of stills and boiler plant to be let under a separate contract. Private plans.

Calif., Los Angeles—Bids Apr. 15, by Metropolitan Water Dist., F. E. Weymond, engr., 306 West 3rd St., 15,000 volt indoor type disconnecting switches, switch and bus compartments, bus insulator units for use in each of the five pumping plants on the line of the Colorado River Aqueduct, Spec. 194, $50,000. Bidding schedule has been divided into 5 schedules, each schedule includes complete equipment for 1 pumping plant. Bids may be submitted for 1 or more schedules but none will be considered for less than all items of any one schedule.

Calif., Oakland—Pacific Gas & Electric Co., 245 Market St., San Francisco, plans substation, 1st and Grove Sts. $1,000,000. Engineering Dpt. of owners, engrs. Foundation for above awarded to Barrett & Hilp, 918 Harrison St., San Francisco, **$55,000.**

Connecticut—Connecticut Light & Power Co., 36 Pear St., Hartford, plans expending $5,027,099 during 1937, incl. $1,578,000 for 25,000 kw. steam turbo-generator at Montville plant, other divisions are $628,300 for transmission, $422,049 for sub-station improvements, $419,500 for electric distribution expansion and $261,850 for office and service buildings.

Conn., Derby—Derby Gas & Electric Co., 22 Elizabeth St., plans power plant extension, Housatonic Ave. $140,000. Private plans.

Conn., Willimantic—State, State Bd. Educ., State Office Bldg., Hartford, plans power plant at Teachers' College. $75,000. Architect not appointed.

Ill., Chicago—Commonwealth Edison Co., 72 West Adams St., allotted $4,000,000 in 1937 budget for expanding generating plant at Lake Michigan on Illinois-Indiana State Line.

Ill., Greenup—Village, E. M. Kohler, mayor, sketches improvements to power plant, $25,000-$45,000. W. A. Fuller Co., 2916 Shenandoah Ave., St. Louis, engrs.

Ill., Joliet—Public Service Co. of Northern Illinois, 72 West Adams St., Chicago, plans enlarging, modernizing and increasing capacity of Joliet electric generating station. $2,600,000. **Maturity indefinite.**

Ind., Edwardsport—Public Service Co. of Indiana, Traction Terminal Bldg., Indianapolis, plans constructing steam electric power plant and addition. $360,000.

Ia., Ackley—Town Council plans and specifications to be adopted Mar. 22, bids later improving municipal electric light and power plant, incl. 375 hp. diesel engine, with 250 kilowatt generator with necessary auxiliary equipment. Total est. $34,500.

Ia., Bradford—Federated Co-Operative Power Assn., R. Mason, pres., Bradford, plans constructing power plant and power lines to supply power for Hardin, Franklin, Wright, Grundy and Butler Counties. $225,000. Owner signed contract with R.E.A.

Ia., Forest City—City opening of bids held up by injunction until April, constructing light and power plant, diesel engines, electrical equipment with switchboard, wiring, cooling tower, oil tanks. $165,000. Young & Stanley, Muscatine, engrs.

Ia., Muscatine—Eastern Iowa Power & Light Co-Operative, 1394 West 4th St., Davenport, plans constructing hydro-electric power development on Cedar River, incl. diverting river above Muscatine to supply electricity to 24 counties in Iowa and 13 counties in Illinois, constructing dam to form 11,000 acres on Cedar River, diversion canal, small dam to form 460 acre lake, and power spillway dam with spillway extending to Mississippi River. $10,000,000. Owner applied for P.W.A. funds. H. Strong, 1304 West 4th St., Davenport, engrs.

Ia., Pocohontas—Central Electric Co-Operative Assn. plans constructing generating plant. $185,000 allotted by R.E.A.

Kan., Goodland—City plans municipal light plant. $200,000. E. T. Archer & Co., New England Bldg., Kansas City, Mo., engrs.

Kan., Paola—Municipality plans electric light plant and distribution system and additions to present water system. $225,000. W. B. Rollins & Co., Railway Exchange Bldg., Kansas City, Mo., engrs.

La., Opelousas—City, preparing plans and soon takes bids for purchase and installation of electric generating unit to be used in rural and city electrification program. D. Hollier, Opelousas, engr.

Mass., Northboro—Town, R. M. Leland, moderator, Town Hall, plans municipal light and power plant. To exceed $40,000. Action to be taken at Town meeting this month. Engineer not appointed.

Md., Cumberland—Mayor and City Council are directed by a bill which has been introduced in the General Assembly to submit the question of establishing a municipal electric plant to the voters of the city at next municipal election. It provides that if the plan is approved the city will borrow $2,000,000 to carry out the project.

Mass., West Groton—Groton Leather Board Co., W. L. Sheedy, pres., plans 1 story, 25x50 ft., 18 ft. high, concrete and structural steel boiler room addition, new boiler, equipment, etc. $40,000. Albert B. Franklin, Inc., 38 Chauncy St., Boston, Mass., engrs.

Mich., Owosso—City, W. Bennett, Dpt. P. Utilities, plans municipal lighting plant, $200,000. C. J. Simon, 14144 Manning Ave., Detroit, engr.

Mo., Springfield—Springfield Gas & Electric Co. plans furnishing, installing additional 12,500 kw. steam turbo-generator with necessary accessories in plant. Est. about $650,000. Private plans.

Mont., Great Falls—City, constructing municipal light and power plant. Mayor A. J. Fousek has applied to City Council for authority to spend $7,000 to employ special engineers to make survey as to possibilities for construction such a plant. A. J. Cook, city engr.

Neb., Lincoln—Chicago, Burlington & Quincy R. R. Co., A. W. Newton, ch. engr., 547 West Jackson Blvd., Chicago, Ill., plans constructing live steam plant. $150,000.

Neb., Minatare—City approved $46,000 bonds for constructing municipal power plant, should they not be able to purchase privately owned plant, here.

Neb., Omaha—Nebraska Power Co., Ralston St., making plans constructing power plant. $1,250,000. F. E. Smith, c/o owner, ch. engr. Metropolitan Utilities District, signed contract for extension of 6 years to Northern National Gas Co. to supply natural gas for proposed power plant to use as fuel, this plant to be located at South Omaha to supply power to four large packing companies, all of whom signed contract to use power.

New Jersey—Public Service Corp. of New Jersey, 80 Park Pl., Newark, new construction and improvement budget for 1937 includes about $18,000,000 to be expended by Public Service Electric & Gas Co., among the larger items 58 kw. turbine generator and 2 high pressure, high temperature boilers at Essex generating station; high tension transmission line between Essex Station and Metuchen; second transmission line between Hudson switching station in Jersey City and site in Bergen County; new power substation, line extensions, etc., Hillside; improvements to outdoor high tension switching facilities in Kearney; generating station; boiler house addition at artificial gas plant, Harrison; placing electric distribution facilities underground. Engineering plans by owner.

N. J., Teterboro—Bendix Aviation Corp., 230 Park Ave., New York, plans by D. H. Barnham & G. H. Benjamin, South Bend, Ind., constructing group of buildings, incl. power plant. $1,500,000. Noted Feb. 23, C.D.—Feb. 25, E.N.-R.

N. Y., Buffalo—Dpt. Mental Hygiene, State Office Bldg., Albany, purchasing and installing new electric generator in Buffalo State Hospital. $50,000. **Maturity probably in 1937.** T. F. Farrell, State Bldg., Albany, engr.

N. Y., Macedon—Hartmann C. L. Corp., W. J. Hartman, pres., 18 North Union St., Rochester, plans purchasing and installing $30,000 worth of canning machinery and equipment in former Dairymen's League plant, incl. transmission and conveying machinery, power plant equipment.

O., Alliance—Municipality plans by W. D. Sponseller, c/o owner, electric light and power plant. To exceed $40,000. **Maturity indefinite.**

O., Bellefontaine—City soon takes bids furnishing 3 automatic generator voltage regulators, $1,800; one 300 AMP switchboard panel, complete $900; one oil purifier for 3,000 kw. turbine generator $800; and one 20-ton hand operated traveling crane $3,000; coal handling and storage equipment $12,000.

O., Lorain—Ohio Pub. Serv. Co., E. J. Burger, mgr. Lorain Division, plans constructing generating plant at Oberlin Ave. to supply northern Ohio area. $4,000,000. City Council clears way for Ohio Pub. Serv. Co. to obtain 50 year lease on land. Private plans.

O., Middletown—City plans constructing municipal light plant. W. Brown, City Mgr. **Maturity indefinite.**

Okla., Blackwell—City sketches made constructing new 4,000 kw. steam turbine addition to Blackwell Power plant. $300,000. Black & Veatch, 4706 Bway., Kansas City, Mo., engrs.

Okla., Randolph—Oklahoma Gas & Electric Co., 321 North Harvey St., preliminary plans constructing steam turbine generator plant on Washita River, near here. $1,000,000. Byllesby Eng. Co., 231 South LaSalle St., Chicago, Ill., engrs.

Pa., Lehighton—Borough, W. Weyhenmeyer, pres., plans municipal light and power plant. $160,000. Architect not appointed. Maturity sometime before 1942 when contract with present utility company expires.

Pa., Pittsburgh—Duquesne Light Co., F. R. Phillips, pres., 435 6th Ave., power station, installing one 60,000 kw. turbine, generating unit, 2 boilers with accessory equipment, at Brunots Island. Owner and Public Utility Eng. & Service Corp., engrs., 231 South La Salle St., Chicago, Ill., build by day labor. $4,000,000.

Pa., Scranton—Comrs. Lackawanna Co., S. G., Mastrianni, co. engr., Court House, plans 2 story, West Mountain Sanatorium, having 2 wings, central power house, etc. $500,000. P.W.A. project. A. J. Ward, 1107 Woodlawn Ave., archt.

Tex., Beaumont—Gulf States Utilities Co., c/o F. C. Terrell, plans new generating unit at Neches Power Station on Neches River, near here, incl. 84x90 ft. turbine house extension, 52x60 ft. boiler house extension, 42x50 ft. control bay addition, equipment includes 25,000 kw. auxiliary generator, 45,000 hp. tandem compound turbine, 29,000 sq. ft., a pass surface condenser, steam generator for 900 lbs. pressure, 915 degree Fahrenheit steam temperature, necessary auxiliaries and electric switching equipment. Private plans.

Tex., Huntsville — Huntsville State Prison, plans electric power plant. $125,000. Appropriation approved by House and project now assured. Engineer, c/o owner, engr.

Vt., Hardwick—Town, G. W. Larrabee, clk., plans altering and constructing power plant addition, constructing new water wheel, steel tank, etc., $56,000. Chas. T. Main, Inc., Devonshire St., Boston, Mass., engrs.

Wash., Beverly Park—Pudget Sound Power & Light Co., 7th and Olive Sts., Seattle, constructing 40x50 ft. sub-station addition, day labor and separate contracts. $100,000. T. H. Campbell, c/o owner, engr. Will install 25,000 kilowatt condenser.

Wash., East Sound—Orcas Electric Co. plans constructing 70 mi. distribution lines and diesel generating plant. $87,000 allotted by REA.

Wash., Seattle—Bids Apr. 1, by Bd. P. Wks., City Light Bldg., furnishing, erecting 560 galvanized steel towers, on 116 mi. line from Newhalem to Seattle. $1,415,000, bids may be in two units (1) for furnishing steel est. $715,000; (2) for work $700,000; also furnishing control and relay switchboard for south receiving sub-station, $27,000. J. D. Ross, city engr.

Wis., Milwaukee—Milwaukee Electric Railway & Lighting Co., 231 West Michigan St., plans expending $3,565,000 for replacements and expansion during 1937, incl. installing boiler in heating plant at North Edison and West Wells St., $1,283,000; also building for same.

Man., Winnipeg — Winnipeg Hydro-Electric System, 55 Princess St., J. G. Glassco, mgr., preparing plans improving plant on Winnipeg River. $40,000 voted.

Ontario—Madawaska River Hydro-Electric Power Comn. of Ontario, University Ave., Toronto, plans development of 20,000 to 30,000 hp. and eventually of 120,000 hp. from river by dam and storage lakes at High Falls, Madawaska River, for use in Eastern Ontario. To exceed $200,000. Private plans.

Ont., London—Public Utilities Comn., E. V. Buchanan, genl. mgr., plans purchasing one 1500 kva. transformer and rearrangement in downtown dist. of power lines, many to be put underground in conduits. $25,000. Work to start May 1.

Ont., Schreiber—Ontario Paper Co., Thorold (subsidiary of Chicago Tribune, Chicago, Ill.), making surveys for power development and river work at Jackfish, near here, $200,000. Owners engineers in charge.

Que., Valleyfield—Municipality making plans constructing municipal power plant. $150,000. R. Belanger, Town Hall, engr.